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Bibliography of Lewis Research Center Technical Publications Announced in 1980

May 1981

NASA

PREFACE

In 1980, Lewis' 1020 research authors published 427 technical publications which were announced to and reached the worldwide scientific community. This number was our typical output even though, once again, we had a slight decrease in staff. In recent years, the trend in Lewis publishing has been that each year the number of technical presentations given at seminars, society symposia, and Lewis-hosted conferences has surpassed the record set the previous year. Lewis authors publish approximately 61 percent of their research contributions in outside publications and the rest as NASA research reports. Lewis authors primarily use society proceedings, seminar presentations, and journal and transactions articles to describe their work.

In 1980 the production of 307 contractor-authored research reports was higher than the previous year's output of 294. In addition, 38 patent applications were filed, and 17 patents were issued, fewer numbers than in recent years.

In 1980, the annual award for Best Lewis Publication was presented to J. Anthony Powell, Anthony J. Strazisar, and Richard G. Seasholtz for their paper "Efficient Laser Anemometer for Intra-Rotor Flow Mapping in Turbomachinery," which describes several innovative features of this anemometer. The paper was presented at the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, Louisiana, March 10-13, 1980. A description is given in abstract A80-36140 (p. 111) in this bibliography.

Also in 1980, the American Society of Lubrication Engineers presented the "Captain Alfred E. Hunt Memorial Award" for the best paper appearing in one of its publications to L. D. Wedeven. This paper, coauthored with Professor Cristino Cusano, a summer faculty fellow from the University of Illinois, entitled "Elastohydrodynamic Film Thickness Measurements of Artificially Produced Nonsmooth Surfaces," is described in abstract A80-14720 (p. 102).

All the publications in this collection were announced in the 1980 issues of STAR (Scientific and Technical Aerospace Reports) and IAA (International Aerospace Abstracts).

The arrangement of the material is by NASA subject category, as noted in the Contents. The Lewis-authored items are listed first, followed by the contractor items. Within each of these groups is listed report literature, in N-number sequence, followed by the journal and conference presentations, in A-number sequence.

The various indexes will help locate specific publications by subject, author, contractor organization, contract number, and report number.

George Mandel
Chief, Management Services Division

CONTENTS

01 AERONAUTICS (GENERAL)

N80-21271*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTERIZED SYSTEMS ANALYSIS AND OPTIMIZATION OF AIRCRAFT ENGINE PERFORMANCE, WEIGHT, AND LIFE CYCLE COSTS c07
Laurence H. Fishbach *In* AGARD The Use of Computers as a Design Tool Jan. 1980 15 p refs (For primary document see N80-21243 12-01)
Avail: NTIS HC A19/MF A01 CSCL 21E

The computational techniques are described which are utilized at Lewis Research Center to determine the optimum propulsion systems for future aircraft applications and to identify system tradeoffs and technology requirements. Cycle performance, and engine weight can be calculated along with costs and installation effects as opposed to fuel consumption alone. Almost any conceivable turbine engine cycle can be studied. These computer codes are: NNEP, WATE, LIFCYC, INSTAL, and POD DRG. Examples are given to illustrate how these computer techniques can be applied to analyze and optimize propulsion system fuel consumption, weight and cost for representative types of aircraft and missions. F.O.S.

02 AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

For related information see also *34 Fluid Mechanics and Heat Transfer.*

N80-10128*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COANNULAR SUPERSONIC EJECTOR NOZZLES
Allan R Bishop *In* NASA. Ames Res. Center Workshop on Thrust Augmenting Ejectors Sep. 1979 p 385-396 refs (For primary document see N80-10107 01-02)
Avail: NTIS HC A22/MF A01 CSCL 01A

The nozzles described exhibit a flow field which is supersonic except for the initial flow region, and the secondary mass flow is typically about five percent of the primary core flow. The features to improve the accuracy of the performance calculations are discussed. A special calculation is made to get as realistic a sonic line as possible for this geometry, using an analysis developed by Brown. The mixing between the secondary and core flows is treated to account for entrainment of the secondary flow into core. Both of these phenomena directly affect the pressure distribution on the shroud and therefore, the thrust that the nozzle produces. The importance of using a realistic sonic line and a mixing analysis is stressed. M.M.M.

N80-11037*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL STUDY OF LOW ASPECT RATIO COMPRESSOR BLADING
Lonnie Reid and Royce D. Moore 1979 19 p refs Proposed for presentation at the 25th Ann. Intern. Gas Turbine Conf., New Orleans, La., 9-13 Mar. 1980; sponsored by Am. Soc. of Mech. Engr.
(NASA-TM-79280; E-217) Avail: NTIS HC A02/MF A01 CSCL 01A

The effects of low aspect ratio blading on aerodynamic performance were examined. Four individual transonic compressor stages, representative of the inlet stage of an advanced high pressure ratio core compressor, are discussed. The flow phenomena for the four stages are investigated. Comparisons of blade element parameters are presented for the two different aspect ratio configurations. Blade loading levels are compared for the near stall conditions and comparisons are made of loss and diffusion factors over the operating range of incidence angles. A.W.H.

N80-14050*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LASER ANEMOMETER MEASUREMENTS IN A TRANSONIC AXIAL FLOW COMPRESSOR ROTOR
Anthony J. Strazisar and J. Anthony Powell 1979 17 p refs Presented at 25th Ann. Intern. Gas Turbine Conf. and 22d Ann. Fluids Engr. Conf., New Orleans, 9-13 Mar. 1970; sponsored by ASME
(NASA-TM-79323; E-279) Avail: NTIS HC A02/MF A01 CSCL 01A

A laser anemometer system employing an efficient data acquisition technique was used to make measurements upstream, within, and downstream of the compressor rotor. A fluorescent dye technique allowed measurements within endwall boundary layers. Adjustable laser beam orientation minimized shadowed regions and enabled radial velocity measurements outside of the blade row. The flow phenomena investigated include flow variations from passage to passage, the rotor shock system, three-dimensional flows in the blade wake, and the development of the outer endwall boundary layer. Laser anemometer measurements are compared to a numerical solution of the streamfunction equations and to measurements made with conventional instrumentation. Author

N80-14051*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MODIFICATION OF AXIAL COMPRESSOR STREAMLINE PROGRAM FOR ANALYSIS OF ENGINE TEST DATA
Jeffrey G. Williams Nov. 1979 49 p refs
(NASA-TM-79312; E-268) Avail: NTIS HC A03/MF A01 CSCL 01A

An existing axial compressor streamline analysis computer program to allow input of measured radial pressure and temperature profiles obtained from engine or cascade data is described. The proposed modifications increase the input flexibility and are accomplished without changing the computer program's input format. A.R.H.

N80-15051*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUMMARY OF ADVANCED METHODS FOR PREDICTING HIGH SPEED PROPELLER PERFORMANCE
L. A. Bober 1980 14 p refs Presented at 18th Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980; sponsored by AIAA
(NASA-TM-81409) Avail: NTIS HC A02/MF A01 CSCL 01A

Three advanced analyses for predicting aircraft propeller performance at high subsonic speeds are described. Two of these analyses use a lifting line representation for the propeller blades and vortex filaments for the blade wakes but differ in the details of the solution. The third analysis is a finite difference solution of the unsteady, three dimensional Euler equations for the flow between adjacent blades. Analysis results are compared to data for a high speed propeller having eight swept blades integrally designed with the spinner and nacelle. Author

N80-17030*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
PREDICTION METHOD FOR TWO-DIMENSIONAL AERODYNAMIC LOSSES OF COOLED VANES USING INTEGRAL BOUNDARY-LAYER PARAMETERS
Louis J. Goldman and Raymond E. Augler Feb. 1980 43 p refs
(NASA-TP-1623; E-076) Avail: NTIS HC A03/MF A01 CSCL 01A

A generalized analysis to predict the two-dimensional aerodynamic losses of film-cooled vanes by using integral boundary-layer parameters is presented. Heat-transfer and trailing-edge injection effects are included in the method. An approximate solution of the generalized equations is also included to show more clearly the effect of the different boundary-layer and cooling parameters on the losses. The analytical predictions agree well with the experimental results, indicating that available boundary-layer calculations for cooled vanes are of sufficient accuracy to use in the prediction method. Author

N80-21285*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH SPEED TURBOPROPS FOR EXECUTIVE AIRCRAFT, POTENTIAL AND RECENT TEST RESULTS
Daniel C. Mikkelson and Glenn A. Mitchell 1980 26 p refs Presented for the Turbine-Powered Executive Meeting, (Phoenix), 9-11 Apr. 1980, sponsored by the Soc. of Automotive Engr.
(NASA-TM-81482; E-419) Avail: NTIS HC A03/MF A01 CSCL 01A

Four high speed propeller models were designed and tested in an 8x6 foot wind tunnel in order to evaluate the potential of advanced propeller technology. Results from these tests show that the combination of: increased blade number, aerodynamically integrated propeller/nacelles, reduced blade thickness, spinner area ruling, and blade sweep are important in achieving high propeller efficiency at the high cruise speeds. R.E.S.

N80-27284*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CAS2D: FORTRAN PROGRAM FOR NONROTATING BLADE-TO-BLADE, STEADY, POTENTIAL TRANSONIC CASCADE FLOWS
Djordje S. Dulikravich Jul. 1980 36 p refs
(NASA-TP-1705; E-253) Avail: NTIS HC A03/MF A01 CSCL 01A

An exact, full-potential-equation (FPE) model for the steady, irrotational, homentropic and homoenergetic flow of a compressible, homocompositional, inviscid fluid through two dimensional planar cascades of airfoils was derived, together with its appropriate boundary conditions. A computer program, CAS2D, was developed that numerically solves an artificially time-dependent form of the actual FPE. The governing equation was discretized by using type-dependent, rotated finite differencing and the finite area technique. The flow field was discretized by providing a boundary-fitted, nonuniform computational mesh. The mesh was generated by using a sequence of conforming mapping, nonorthogonal coordinate stretching, and local, isoparametric, bilinear mapping functions. The discretized form of the FPE was solved iteratively by using successive line overrelaxation. The possible isentropic shocks were correctly captured by adding explicitly an artificial viscosity in a conservative form. In addition, a three-level consecutive, mesh refinement feature makes CAS2D a reliable and fast algorithm for the analysis of transonic, two dimensional cascade flows. Author

N80-27286*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN ALTERNATIVE APPROACH TO THE NUMERICAL SIMULATION OF STEADY INVISCID FLOW
Gary M. Johnson Jun. 1980 8 p refs Presented at 7th Intern. Conf. on Numerical Methods in Fluid Dyn., Stanford, Calif., 23-27 Jun. 1980; sponsored by NACA, AFOSR, NSF, and ONR
(NASA-TM-81542) Avail: NTIS HC A02/MF A01

A numerical procedure for the efficient simulation of steady inviscid flow is described and its utility demonstrated. Application of the surrogate equation technique allows the formulation of stable, fully conservative, type dependent finite difference equations for use in obtaining numerical solutions to systems of first order partial differential equations, such as the steady state Euler equations or their various approximations. Computational results are presented for the full Euler equations and for the transonic disturbance equations. For the latter case, a computational efficiency greater than that obtained by means of the standard perturbation potential approach is indicated. E.D.K.

N80-33357*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WIND: COMPUTER PROGRAM FOR CALCULATION OF THREE DIMENSIONAL POTENTIAL COMPRESSIBLE FLOW ABOUT WIND TURBINE ROTOR BLADES
Djordje S. Dulikravich Oct. 1980 20 p refs
(NASA-TP-1729; E-474) Avail: NTIS HC A02/MF A01 CSCL 01A

A computer program is presented which numerically solves an exact, full potential equation (FPE) for three dimensional, steady, inviscid flow through an isolated wind turbine rotor. The program automatically generates a three dimensional, boundary conforming grid and iteratively solves the FPE while fully accounting for both the rotating cascade and Coriolis effects. The numerical techniques incorporated involve rotated, type dependent finite differencing, a finite volume method, artificial viscosity in conservative form, and a successive line overrelaxation combined with the sequential grid refinement procedure to accelerate the iterative convergence rate. Consequently, the WIND program is capable of accurately analyzing incompressible and compressible flows, including those that are locally transonic and terminated by weak shocks. The program can also be used to analyze the flow around isolated aircraft propellers and helicopter rotors in hover as long as the total relative Mach number of the oncoming flow is subsonic. A.R.H.

A80-20966 * // **Summary of advanced methods for predicting high speed propeller performance.** L. J. Bober and G. A. Mitchell (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0225.* 12 p. 10 refs.

Three advanced analyses for predicting aircraft propeller performance at high subsonic speeds are described. Two of these analyses use a lifting line representation for the propeller blades and vortex filaments for the blade wakes but differ in the details of the solution. The third analysis is a finite difference solution of the unsteady, three-dimensional Euler equations for the flow between adjacent blades. Analysis results are compared to data for a high speed propeller having 8 swept blades integrally designed with the spinner and nacelle. These analyses provide tools for the propeller designer ranging from a short running program for initial design studies to a very long running program for checking final configurations. (Author)

A80-20967 * // **Computation of three-dimensional flow in turbofan mixers and comparison with experimental data.** L. A. Povinelli, B. H. Anderson, and W. Gerstenmaier (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0227.* 10 p. 7 refs.

A three-dimensional, viscous computer code was used to calculate the mixing downstream of a typical turbofan mixer geometry. Experimental data were obtained using pressure and temperature rakes at the lobe and nozzle exit stations. Secondary flow velocities were also obtained. These data were used to validate the computer results. An assessment was also made to determine the relative importance of turbulence in the mixing phenomenon as compared with the streamwise vorticity set up by the secondary flows. The observations suggest that the generation of streamwise vorticity appears to play a significant role in determining the temperature distribution at the nozzle exit plane. (Author)

A80-20969 * // **Numerical simulation of supersonic inlets using a three-dimensional viscous flow analysis.** B. H. Anderson and C. E. Towne (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0384.* 15 p. 20 refs.

A three-dimensional fully viscous computer analysis, which retains the viscous nature of the Navier-Stokes equations, was evaluated to determine its usefulness in the design of supersonic inlets. This procedure takes advantage of physical approximations to limit the high computer time and storage associated with complete Navier-Stokes solutions. Computed results are presented for a Mach 3.0 supersonic inlet with bleed and a Mach 7.4 hypersonic inlet. Good agreement was obtained between theory and data for both inlets. Results of a mesh sensitivity study are also shown. (Author)

A80-38897 * // **Comparison between optical measurements and a numerical solution of the flow field within a transonic axial-flow compressor rotor.** A. J. Strazisar and R. V. Chima (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1078.* 10 p. 11 refs.

A comparison between numerical and experimental results is presented for the flowfield within a transonic axial-flow compressor rotor. The rotor was tested at design speed and a wide open throttle discharge condition. The relative tip Mach number was 1.4. A laser anemometer system was used to measure velocity and flow angle upstream, within, and downstream of the rotor. A holographic interferometer was used to visualize the rotor shock system near the tip. The computational procedure solves the full three-dimensional Euler equations using a time-marching technique. Shock location and shape determined from the two optical systems are compared. Calculated relative Mach number and flow angle contours, shock locations, and shock strength are compared to values measured with the laser anemometer. (Author)

A80-38904 * # **An experimental investigation of endwall profiling in a turbine vane cascade.** F. C. Kopper, R. Milano (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.), and M. Vanco (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1089.* 10 p. 18 refs. Contract No. NAS3-20646.

Measurements of surface static pressures, flow total pressure loss, and exit air angle were obtained for two linear cascades to establish the effects of endwall profiling. Testing was conducted at an isentropic exit Mach number of 0.85. One cascade was fabricated with planar endwalls while the other had one planar and one profiled endwall. Both cascades utilized the same high pressure turbine inlet guide vane section. It was found that in terms of full passage loss the profiled endwall cascade has the superior performance. The secondary loss results obtained are reasonably well predicted by correlations developed from incompressible flow testing of similar configurations. Inviscid flow and boundary layer calculations are compared with the test data, and overall, the agreement is found to be good. Use of the results for design purposes is briefly discussed. (Author)

A80-41203 * # **Zero-length, slotted-lip inlet for subsonic military aircraft.** E. R. Glasgow, W. E. Beck (Lockheed-California Co., Burbank, Calif.), and R. R. Woollett (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1245.* 13 p. 24 refs. Contract No. NAS3-21461.

Zero-length, slotted-lip inlet performance and associated fan blade stresses were determined during model tests using a 20-inch diameter fan simulator in the NASA-LeRC 9- by 15-foot low-speed wind tunnel. The model configuration variables consisted of inlet contraction ratio, slot width, circumferential extent of slot fillers, and length of a constant area section between the inlet throat and fan face. Inlet configurations having contraction ratios of 1.2 and 1.3 satisfied all critical low-speed inlet operating requirements for a fixed horizontal nacelle and tilt-nacelle-type subsonic V/STOL aircraft, respectively. Relative to a conventional axisymmetric tilt-nacelle inlet, the zero-length, slotted-lip inlet has a 27-percent smaller inlet lip contraction ratio, an 83-percent shorter total length, and a 5-percent smaller maximum cowl diameter. (Author)

A80-42145 * # **Streakline flow visualization study of a horseshoe vortex in a large-scale, two-dimensional turbine stator cascade.** R. E. Gaugler and L. M. Russell (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-4.* 8 p. 12 refs. Members, $1.50; nonmembers, $3.00.

Neutrally buoyant helium-filled bubbles were observed as they followed the streamlines in a horseshoe vortex system around the vane leading edge in a large-scale, two-dimensional, turbine stator cascade. Bubbles were introduced into the endwall boundary layer through a slot upstream of the vane leading edge. The paths of the bubbles were recorded photographically as streaklines on 16-mm movie film. Individual frames from the film have been selected, and overlayed to show the details of the horseshoe vortex around the leading edge. The transport of the vortex across the passage near the leading edge is clearly seen when compared to the streaks formed by bubbles carried in the main stream. Limiting streamlines on the endwall surface were traced by the flow of oil drops. (Author)

A80-44229 * # **Numerical calculation of transonic axial turbomachinery flows.** D. S. Dulikravich (NASA, Lewis Research Center, Cleveland, Ohio). *U.S. Air Force, NASA, NSF, and U.S. Navy, International Conference on Numerical Methods in Fluid Dynamics, 7th, Stanford University, Stanford, Calif., June 23-27, 1980, Paper.* 8 p. 15 refs.

This paper presents a numerical method and the results of a computer program for solving an exact, three-dimensional, full-potential equation that models rotating and nonrotating inviscid, absolutely irrotational, homentropic flows. Besides calculating the flows through an arbitrarily shaped rotor or stator blade row mounted on an axisymmetric hub and confined in an axisymmetric duct, the computer program is also capable of analysing flow fields about arbitrarily shaped wing-body combinations, propellers, helicopter rotors in hover, and wind turbine rotors. The governing equation is solved numerically in a fully conservative form by using an artificial time concept, a finite volume technique, rotated type-dependent differencing, successive line overrelaxation, and sequential boundary-conforming grid refinement. An artificial viscosity is added in fully conservative form; and an initial guess for the potential field is applied, as determined by a two-dimensional cascade analysis. (Author)

A80-44862 * **The effect of finite turbulence spatial scale on the amplification of turbulence by a contracting stream.** M. E. Goldstein (NASA, Lewis Research Center, Cleveland, Ohio) and P. A. Durbin (Cambridge University, Cambridge, England). *Journal of Fluid Mechanics,* vol. 98, June 12, 1980, p. 473-508. 23 refs.

The turbulence downstream of a rapid contraction is calculated for the case when the turbulence scale can have the same magnitude as the mean-flow spatial scale. The approach used is based on the formulation of Goldstein (1978) for turbulence downstream of a contraction, with the added assumptions of a parallel mean flow at downstream infinity and turbulence calculated far enough downstream so that the nonuniformity of the mean flow field has decayed, and by treating the inverse contraction ratio as a small parameter. Consideration is given to the large-contraction-ratio and classical rapid-distortion theory limits, and to results at an arbitrary contraction ratio. It is shown that the amplification effect of the contraction is reduced when the spatial scale of the turbulence increases, with the upstream turbulence actually suppressed for a contraction ratio less than five and a turbulence spatial scale greater than three times the transverse dimensions of the downstream channel. A.L.W.

N80-10134*# Douglas Aircraft Co., Inc., Long Beach, Calif.
AN EFFICIENT USER-ORIENTED METHOD FOR CALCULATING COMPRESSIBLE FLOW IN AN ABOUT THREE-DIMENSIONAL INLETS Final Report, Nov. 1977 - Apr. 1979
John I. Hess, Dun-Pok Mack, and Norbert O. Stockman (NASA, Lewis Res. Center) Apr. 1979 117 p refs
(Contract NAS3-21135)
(NASA-CR-159578; MDC-J7733) Avail: NTIS HC A06/MF A01 CSCL 01A

A panel method is used to calculate incompressible flow about arbitrary three-dimensional inlets with or without centerbodies for four fundamental flow conditions: unit onset flows parallel to each of the coordinate axes plus static operation. The computing time is scarcely longer than for a single solution. A linear superposition of these solutions quite rigorously gives incompressible flow about the inlet for any angle of attack, angle of yaw, and mass flow rate. Compressibility is accounted for by applying a well-proven correction to the incompressible flow. Since the computing times for the combination and the compressibility correction are small, flows at a large number of inlet operating conditions are obtained rather cheaply. Geometric input is aided by an automatic generating program. A number of graphical output features are provided to aid the user, including surface streamline tracing and automatic generation of curves of curves of constant pressure, Mach number, and flow inclination

N80-17995*# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Applied Mechanics.
A CALCULATION PROCEDURE FOR VISCOUS FLOW IN TURBOMACHINES, VOLUME 2
J. Khalil and W. Tabakoff Jan. 1980 54 p refs
(Contract NAS3-21509; DA Proj. 1L1-61102-AH-45)
(NASA-CR-159636) Avail: NTIS HC A04/MF A01 CSCL 21E

Turbulent flow within turbomachines having arbitrary blade geometries is examined. Effects of turbulence are modeled using two equations, one expressing the development of the turbulence kinetic energy and the other its dissipation rate. To account for complicated blade geometries, the flow equations are formulated in terms of a nonorthogonal boundary fitted coordinate system. The analysis is applied to a radial inflow turbine. The solution obtained indicates the severity of the complex interaction mechanism that occurs between the different flow regimes (i.e., boundary layers, recirculating eddies, separation zones, etc.). Comparison with nonviscous flow solutions tend to justify strongly the inadequacy of using the latter with standard boundary layer techniques to obtain viscous flow details within turbomachine rotors. Capabilities and limitations of the present method of analysis are discussed. M.G.

N80-24263*# General Dynamics/Fort Worth, Tex.
EXPERIMENTAL INVESTIGATION OF A 0.15 SCALE MODEL OF A CONFORMAL VARIABLE-RAMP INLET FOR THE F-16 AIRPLANE Final Report
J. E. Hawkins Mar. 1980 219 p refs Sponsored by NASA
(NASA-CR-159640; ERR-FW-2014) Avail: NTIS HC A10/MF A01 CSCL 01A

A 0.15 scale model of a proposed conformal variable-ramp inlet for the Multirole Fighter was tested from Mach 0.8 to 2.2 at a wide range of angles of attack and sideslip. Inlet ramp angle was varied to optimize ramp angle as a function of engine airflow, Mach number, angle of attack, and angle of sideslip. Several inlet configuration options were investigated to study their effects on inlet operation and to establish the final flight configuration. These variations were cowl sidewall cutback, cowl lip bluntness, boundary layer bleed, and first-ramp leading edge shape. Diagnostic and engine face instrumentation were used to evaluate inlet operation at various inlet stations and at the inlet/engine interface. Pressure recovery and stability of the inlet were satisfactory for the proposed application. On the basis of an engine stability audit of the worst-case instantaneous distortion patterns, no inlet/engine compatibility problems are expected for normal operations. Author

N80-26274*# Cincinnati Univ., Ohio.
A CALCULATION PROCEDURE FOR VISCOUS FLOW IN TURBOMACHINES, VOLUME 3
I. Khalil, Y. Sheoran, and W. Tabakoff Jun. 1980 46 p
(Contract NAS3-21609)
(NASA-CR-159864) Avail: NTIS HC A03/MF A01 CSCL 01A

A method for analyzing the nonadiabatic viscous flow through turbomachine blade passages was developed. The field analysis is based upon the numerical integration of the full incompressible Navier-Stokes equations, together with the energy equation on the blade-to-blade surface. A FORTRAN IV computer program was written based on this method. The numerical code used to solve the governing equations employs a nonorthogonal boundary fitted coordinate system. The flow may be axial, radial or mixed and there may be a change in stream channel thickness in the through-flow direction. The inputs required for two FORTRAN IV programs are presented. The first program considers laminar flows and the second can handle turbulent flows. Numerical examples are included to illustrate the use of the program, and to show the results that are obtained. A.R.H.

N80-27288*# Pennsylvania State Univ., University Park.
THREE DIMENSIONAL MEAN FLOW AND TURBULENCE CHARACTERISTICS OF THE NEAR WAKE OF A COMPRESSOR ROTOR BLADE Final Report
A. Ravindranath and B. Lakshminarayana Jun. 1980 298 p refs
(Grant NsG-3012)
(NASA-CR-159518; PSU-TURBO-R-80-4) Avail: NTIS HC A13/MF A01 CSCL 01A

The investigation was carried out using the rotating hot wire technique. Measurements were taken inside the end wall boundary layer to discern the effect of annulus and hub wall boundary layer, secondary flow, and tip leakage on the wake structure. Static pressure gradients across the wake were measured using a static stagnation pressure probe insensitive to flow direction changes. The axial and the tangential velocity defects, the radial component of velocity, and turbulence intensities were found to be very large as compared to the near and far wake regions. The radial velocities in the trailing edge region exhibited characteristics prevalent in a trailing vortex system. Flow near the blade tips found to be highly complex due to interaction of the end wall boundary layers, secondary flows, and tip leakage flow with the wake. The streamwise curvature was found to be appreciable near the blade trailing edge. Flow properties in the trailing edge region are quite different compared to that in the near and far wake regions with respect to their decay characteristics, similarity, etc. Fourier decomposition of the rotor wake revealed that for a normalized wake only the first three coefficients are dominant. E.D.K.

N80-28302*# Atmospheric Science Associates, Bedford, Mass.
CALCULATION OF WATER DROP TRAJECTORIES TO AND ABOUT ARBITRARY THREE-DIMENSIONAL BODIES IN POTENTIAL AIRFLOW Final Report
Hillyer G. Norment Washington NASA Aug. 1980 83 p refs
(Contract NAS3-22199)
(NASA-CR-3291) Avail: NTIS HC A05/MF A01 CSCL 20D

Calculations can be performed for any atmospheric conditions and for all water drop sizes, from the smallest cloud droplet to large raindrops. Any subsonic, external, non-lifting flow can be accommodated; flow into, but not through, inlets also can be simulated. Experimental water drop drag relations are used in the water drop equations of motion and effects of gravity settling are included. Seven codes are described: (1) a code used to debug and plot body surface description data; (2) a code that processes the body surface data to yield the potential flow field, (3) a code that computes flow velocities at arrays of points in space; (4) a code that computes water drop trajectories from an array of points in space; (5) a code that computes water drop trajectories and fluxes to arbitrary target points, (6) a code that computes water drop trajectories tangent to the body; and (7) a code that produces stereo pair plots which include both the body and trajectories. Code descriptions include operating instructions, card inputs and printouts for example problems, and listing of the FORTRAN codes. Accuracy of the calculations is discussed, and trajectory calculation results are compared with prior calculations and with experimental data. Author

N80-29251*# Stanitz (John D.), University Heights, Ohio.
GENERAL DESIGN METHOD FOR THREE-DIMENSIONAL POTENTIAL FLOW FIELDS. 1: THEORY Final Report
John D. Stanitz Washington, D.C. Aug. 1980 82 p refs
(Contract NAS3-21605)
(NASA-CR-3288) Avail: NTIS HC A05/MF A01 CSCL 01A

A general design method was developed for steady, three dimensional, potential, incompressible or subsonic-compressible flow. In this design method, the flow field, including the shape of its boundary, was determined for arbitrarily specified, continuous distributions of velocity as a function of arc length along the boundary streamlines. The method applied to the design of both internal and external flow fields, including, in both cases, fields with planar symmetry. The analytic problems associated with stagnation points, closure of bodies in external flow fields, and prediction of turning angles in three dimensional ducts were reviewed. R.C.T.

N80-31351*# United Technologies Research Center, East Hartford, Conn.
INFLUENCE OF MISTUNING ON BLADE TORSIONAL FLUTTER
A. V. Srinivasan Aug. 1980 55 p refs
(Contract NAS3-21603)
(NASA-CR-165137; R80-914545-16) Avail: NTIS HC A04/MF A01 CSCL 01A

An analytical technique for the prediction of fan blade flutter was evaluated by utilizing first stage fan flutter data from tests on an advanced high performance engine. The formulation includes both aerodynamic and mechanical coupling among all the blades of the assembly. Mistuning is accounted for in the analysis so that individual blade inertias, frequencies, or damping can be considered. Airfoil stability was predicted by calculating a flutter determinant, the eigenvalues of which indicate the extent of susceptibility to flutter. When blade to blade differences in frequencies are considered, a stable system is predicted for the test points examined. For a tuned system, it was found that torsional flutter can be predicted at a limited number of interblade phase angles. Examination of these phase angles indicated that they were 'close' to the condition of acoustic resonance. For the range of Mach numbers and reduced frequencies considered, the so called subcritical flutter cannot be predicted. The essential influence of mechanical coupling among the blades is to change the frequencies of the system with little or no change in damping; however, aerodynamic coupling together with mechanical coupling could change not only frequencies, but also damping in the system, with a trend toward instability. A.R.H.

N80-32328*# Illinois Inst. of Tech., Chicago.
EFFECTS OF AXISYMMETRIC CONTRACTIONS ON TURBULENCE OF VARIOUS SCALES Final Report
Jimmy Tan-atichat, Hassan M. Nagib, and Robert E. Drubka
Sep. 1980 376 p refs
(Grant NsG-3220)
(NASA-CR-165136, R80-1) Avail: NTIS HC A17/MF A01 CSCL 01A

Digitally acquired and processed results from an experimental investigation of grid generated turbulence of various scales through and downstream of nine matched cubic contour contractions ranging in area ratio from 2 to 36, and in length to inlet diameter ratio from 0.25 to 1.50 are reported. An additional contraction with a fifth order contour was also utilized for studying the shape effect. Thirteen homogeneous and nearly isotropic test flow conditions with a range of turbulence intensities, length scales and Reynolds numbers were generated and used to examine the sensitivity of the contractions to upstream turbulence. The extent to which the turbulence is altered by the contraction depends on the incoming turbulence scales, the total strain experienced by the fluid, as well as the contraction ratio and the strain rate. Varying the turbulence integral scale influences the transverse turbulence components more than the streamwise component. In general, the larger the turbulence scale, the lesser the reduction in the turbulence intensity of the transverse components. Best agreement with rapid distortion theory was obtained for large scale turbulence, where viscous decay over the contraction length was negligible, or when a first order correction for viscous decay was applied to the results. T.M.

A80-18324 * # **Evaluation of a strained-coordinate perturbation procedure - Nonlinear subsonic and transonic flows.** S. S. Stahara, A. J. Crisalli (Nielsen Engineering and Research, Inc., Mountain View, Calif.), and J. R. Spreiter (Stanford University, Stanford, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0339.* 12 p. 9 refs. Contract No. NAS3-20836.

An evaluation is made of a perturbation method devised to obtain highly accurate approximations to families of strongly nonlinear solutions which are either continuous or discontinuous, and which represent variations in some arbitrary parameter. The method first defines a unit perturbation by using two nonlinear solutions which differ from one another by a nominal change in some geometric or flow parameter, then employs this unit perturbation to predict a family of related nonlinear solutions over a range of parameter variation. Coordinate straining is incorporated into this perturbation method for determining the unit perturbation to account for the movement of discontinuities and maxima of high-gradient regions due to the perturbation. Attention is given to transonic and subsonic flows. Comparisons of the perturbation results with the corresponding 'exact' nonlinear solutions show a remarkable accuracy and range of validity of the perturbation method across the spectrum of examples considered. S.D.

A80-20086 # **A phenomenological model of the dynamic stall of a helicopter blade profile (Modèle phénoménologique de décrochage dynamique sur profil de pale d'hélicoptère).** R. Dat, C. T. Tran, and D. Petot (ONERA, Châtillon-sous-Bagneux, Hauts-de-Seine, France). *(Association Aéronautique et Astronautique de France, Colloque d'Aérodynamique Appliquée, 16th, Lille, France, Nov. 13-15, 1979.) ONERA, TP* no. 1979-149, 1979. 43 p. 7 refs. In French.

A phenomenological model developed for the prediction of helicopter blade stall is presented. The model uses a system of procedure for turbulent compressible flow in axisymmetric ducts was used to successfully model the HIMAT duct flow. The analysis technique was further used to estimate the initiation of separation and delineate the steady and unsteady flow regimes in similar S-shaped ducts. (Author)

A80-20748 * # **Griffith diffusers.** T.-T. Yang (Clemson University, Clemson, S.C.) and C. D. Nelson. *ASME, Transactions, Journal of Fluids Engineering,* vol. 101, Dec. 1979, p. 473-477. 13 refs. Research supported by Clemson University; Contracts No. NAS3-13486; No. F33615-74-C-2039; Grant No. NGL-41-001-031.

Contoured wall diffusers are designed by using an inverse method. The prescribed wall velocity distribution(s) was taken from the high lift airfoil designed by A. A. Griffith in 1938; therefore, such diffusers are named Griffith diffusers. First the formulation of the inverse problem and the method of solution are outlined. Then the typical contour of a two-dimensional diffuser and velocity distributions across the flow channel at various stations are presented. For a Griffith diffuser to operate as it is designed, boundary layer suction is necessary. Discussion of the percentage of through-flow required to be removed for the purpose of boundary layer control is given. Finally, reference is made to the latest version of a computer program for a two-dimensional diffuser requiring only area ratio, nondimensional length and suction percentage as inputs. (Author)

A80-38895 * # **Inlet flow distortion in turbomachinery. I - Comparison of theory and experiment in a transonic fan stage. II - A parameter study.** B. S. Seidel, M. D. Matwey (Delaware, University, Newark, Del.), and J. J. Adamczyk (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1076,* 6 p. 7 refs. Grant No. NsG-3189.

In the present paper, a semi-actuator-disk theory is reviewed that was developed previously for the distorted inflow to a single-stage axial-flow compressor. Flow distortion occurs far upstream; it may be a distortion in stagnation temperature, stagnation pressure, or both. Losses, quasi-steady deviation angles, and reference incidence correlations are included in the analysis, and both subsonic and transonic relative Mach numbers are considered. The theory is compared with measurements made in a transonic fan stage, and a parameter study is carried out to determine the influence of solidity on the attenuation of distortions in stagnation pressure and stagnation temperature. V.P.

A80-41601 * # **A three-dimensional turbulent compressible subsonic duct flow analysis for use with constructed coordinate systems.** R. Levy, H. McDonald, W. R. Briley, and J. P. Kreskovsky (Scientific Research Associates, Inc., Glastonbury, Conn.). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 13th, Snowmass, Colo., July 14-16, 1980, Paper 80-1398.* 10 p. 7 refs. Contract No. NAS3-21735.

An approximate analysis, applicable to nonorthogonal coordinate systems having a curved centerline and planar transverse coordinate surfaces normal to the centerline, is presented for computation of three-dimensional subsonic flow in straight and curved diffusers. The formulation is intended to facilitate the use of constructed coordinates in circumstances where it is difficult to maintain smooth behavior in higher derivatives; the use of local Cartesian variables and fluxes leads to governing equations which require only first derivatives of the coordinate transformation. The analysis is applied to a particular family of duct and diffuser geometries having curved centerlines and superelliptic cross sections. Qualitative agreement with experimental measurements is observed with regard to streamwise vortices and distortion of the primary flow. J.P.B.

A80-44128 * # **An implicit finite-difference code for inviscid and viscous cascade flow.** J. L. Steger (Flow Simulations, Inc., Sunnyvale, Calif.), T. H. Pulliam (NASA, Ames Research Center, Moffett Field, Calif.), and R. V. Chima (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 13th, Snowmass, Colo., July 14-16, 1980, Paper 80-1427.* 15 p. 32 refs.

An implicit finite-difference code is developed to solve either inviscid or viscous flow about two-dimensional cascade blade elements. General coordinate transformations are used so that boundaries can coincide with coordinate lines, and an automatic grid generation routine based on elliptic partial differential equations is employed to mesh arbitrary cascade elements. Characteristic combinations of the differential equations are used at inflow and outflow boundaries. Computed results for both inviscid and viscous flow are compared with other existing cascade solutions and experimental data. (Author)

A80-45841 * **Aerodynamic analysis of a supersonic cascade vibrating in a complex mode.** J. E. Caruthers (Tennessee, University, Space Institute, Tullahoma, Tenn.) and R. E. Riffel (General Motors Corp., Detroit Allison Div., Indianapolis, Ind.). *Journal of Sound and Vibration,* vol. 71, July 22, 1980, p. 171-183. 10 refs. Contract No NAS3-20055.

An analysis is presented which has been used to predict the unsteady aerodynamic behavior of a finite supersonic cascade of airfoils forced in harmonic oscillation with airfoil-to-airfoil variations in amplitude. Theoretical predictions are compared with some recent experimental results at a reduced frequency representative of actual fan or compressor flutter cases. The similarity of the experimental situation in the finite cascade to the flutter of a severely mistuned rotor is noted. (Author)

03 AIR TRANSPORTATION AND SAFETY

Includes passenger and ca'..: air transport operations; and aircraft accidents
For related information see also *16 Space Transportat. n* and *85 Urban Technology and Transportation*

N80-15059*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SIMULTANEOUS CABIN AND AMBIENT OZONE MEASUREMENTS ON TWO BOEING 747 AIRPLANES, VOLUME 1
Porter J Perkins, J D Holdeman, and G D Nastrom (Control Data Corp, Minneapolis, Minn) Jul 1979 826 p refs
(NASA-TM-79166; FAA-EE-79-05; E-196) Avail NTIS HC A99/MF A01 CSCL 01C
Measurements of zone concentrations both outside and in the cabin of an airline operated Boeing 747SP and Boeing 747-100 airliner are presented Plotted data and the corresponding tables of observations taken at altitude between the departure and destination airports of each flight are arranged chronologically for the two aircraft Data were taken at five or ten minute intervals by automated instrumentation used in the NACA Global Atmospheric Sampling Program
M M M

04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

For related information see also *17 Spacecraft Communications, Command, and Tracking* and *32 Communications.*

A80-13064 * # **UHF coplanar-slot antenna for aircraft-to-satellite data communications.** R. W. Myhre (NASA, Lewis Research Center, Cleveland, Ohio). *New Mexico State University and U.S. Army, Printed Circuit Antenna Technology Workshop, Las Cruces, N. Mex., Oct. 17-19, 1979, Paper.* 19 p.

The initiative for starting the Aircraft-to-Satellite Data Relay (ASDAR) Program came from a recognition that much of the world's weather originates in the data sparse area of the tropics which are primarily ocean. The ASDAR system consists of (1) a data acquisition and control unit to acquire, store and format these data; (2) a clock to time the data sampling and transmission periods; and (3) a transmitter and low-profile upper hemisphere coverage antenna to relay the formatted data via satellite to the National Weather Service ground stations, as shown schematically. The low-profile antenna is a conformal antenna based on the coplanar-slot approach. The antenna is circular polarized and has an on-axis gain of nearly 2.5 dB and a HPBW greater than 90 deg. The discussion covers antenna design, radiation characteristics, flight testing, and system performance. S.D.

05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.
For related information see also *18 Spacecraft Design, Testing and Performance* and *39 Structural Mechanics.*

A80-15123 * # **Examination of the flap-lag stability of rigid articulated rotor blades.** K. R. V. Kaza (NASA, Lewis Research Center, Cleveland; Toledo, University, Toledo, Ohio) and R. G. Kvaternik (NASA, Langley Research Center, Structures and Dynamics Div., Hampton, Va.). *Journal of Aircraft,* vol. 16, Dec. 1979, p. 876-884. 20 refs.

A critical examination of flap-lag stability of a centrally hinged, spring-restrained rigid blade in both hover and forward flight is presented. Several differences in the equations of motion for blade flap-lag stability in the existing literature are identified. A rigorous and systematic development of these equations for a rigid articulated blade in forward flight shows the existence of some linear aerodynamic coupling terms associated with blade steady-state flapping and lagging in the perturbation equations. The differences identified are shown to be associated with whether or not the lag hinge flaps with the blade. The implications of these differences on stability are examined, and it is shown that the pitch-lag coupling terms associated with a hinge arrangement in which the lag hinge flaps with the blade have a marked influence on flap-lag stability, depending on the system parameters. (Author)

A80-28853 * # **Measurements of cabin and ambient ozone on B747 airplanes.** G. D. Nastrom (Control Data Corp., Minneapolis, Minn.), J. D. Holdeman, and P. J. Perkins (NASA, Lewis Research Center, Combustion and Pollution Research Branch, Cleveland, Ohio). *Journal of Aircraft,* vol. 17, Apr. 1980, p. 246-249. 14 refs. FAA-supported research.

In response to recent concerns over possibly high ozone levels in the cabins of aircraft flying in the stratosphere, simultaneous measurements of the cabin and ambient ozone levels have been made as part of the NASA Global Atmospheric Sampling Program. Examples of the data taken on commercially operated Boeing 747-100 and 747SP airplanes are given for selected flights, together with summary statistics of over 5600 observations. Cabin ozone levels vary with the ambient level and, for unmodified aircraft, are higher on the 747SP than on the 747-100. Modifications to the ventilation system of the 747SP reduced cabin ozone levels by varying amounts up to a factor of 14. (Author)

A80-41193 * # **Development of a Kevlar/PMR-15 reduced drag DC-9 nacelle fairing.** R. T. Kawai (Douglas Aircraft Co., Long Beach, Calif.) and F. J. Hrach (NASA, Lewis Research Center, Engine Component Improvement Office, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1194.* 9 p. 5 refs.

The paper describes an advanced composite fairing designed to reduce drag on DC-9 nacelles as a part of the NASA Engine Component Improvement Program. This fairing is the aft enclosure for the thrust reverser actuator system on JT8D engine nacelles and is subjected to a 500 F exhaust flow during the reverse thrust. A reduced-drag configuration was developed by using in-flight tuft surveys for flow visualization in order to identify areas with low-quality flow, and then modifying the aerodynamic lines to improve the flow. A fabrication method for molding the part in an autoclave was developed; this material system is suitable for 500 F. The resultant composite fairing reduces the overall aircraft drag 1% with a weight reduction of 40% when compared with a metal component. A.T.

A80-41194 * # **Reduced bleed air extraction for DC-10 cabin air conditioning.** W. H. Newman, M. R. Viele (Douglas Aircraft Co., Long Beach, Calif.), and F. J. Hrach (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1197.* 8 p.

It is noted that a significant fuel savings can be achieved by reducing bleed air used for cabin air conditioning. Air in the cabin can be recirculated to maintain comfortable ventilation rates but the quality of the air tends to decrease due to entrainment of smoke and odors. Attention is given to a development system designed and fabricated under the NASA Engine Component Improvement Program to define the recirculation limit for the DC-10. It is shown that with the system, a wide range of bleed air reductions and recirculation rates is possible. A goal of 0.8% fuel savings has been achieved which results from a 50% reduction in bleed extraction from the engine. M.E.P.

N80-16060*# Massachusetts Inst. of Tech., Cambridge.
AIR POLLUTION FROM AIRCRAFT
John B. Heywood, James A. Fay, and Norman A. Chigier (Sheffield Univ.) Oct. 1979 47 p refs
(Grant NGR-22-009-378)
(NASA-CR-159712) Avail: NTIS HC A03/MF A01 CSCL 21E

A series of fundamental problems related to jet engine air pollution and combustion were examined. These include soot formation and oxidation, nitric oxide and carbon monoxide emissions mechanisms, pollutant dispension, flow and combustion characteristics of the NASA swirl can combustor, fuel atomization and fuel-air mixing processes, fuel spray drop velocity and size measurement, ignition and blowout. A summary of this work, and a bibliography of 41 theses and publications which describe this work, with abstracts, is included. A.R.H.

N80-32378*# Douglas Aircraft Co., Inc., Long Beach, Calif.
ENGINE BLEED AIR REDUCTION IN DC-10
W. H. Newman and M. R. Viele Sep. 1980 75 p refs
(Contract NAS3-21763)
(NASA-CR-159846) Avail: NTIS HC A04/MF A01 CSCL 01C

An 0.8 percent fuel savings was achieved by a reduction in engine bleed air through the use of cabin air recirculation. The recirculation system was evaluated in revenue service on a DC-10. The cabin remained comfortable with reductions in cabin fresh air (engine bleed air) as much as 50 percent. Flight test verified the predicted fuel saving of 0.8 percent. R.C.T.

06 AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

For related information see also *19 Spacecraft Instrumentation* and *35 Instrumentation and Photography.*

N80-14110*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

WIND-TUNNEL INVESTIGATION OF THE FLOW CORRECTION FOR A MODEL-MOUNTED ANGLE OF ATTACK SENSOR AT ANGLES OF ATTACK FROM -10 DEG TO 110 DEG

Thomas M. Moul Nov. 1979 20 p refs

(NASA-TM-80189) Avail: NTIS HC A02/MF A01 CSCL 01C

A preliminary wind tunnel investigation was undertaken to determine the flow correction for a vane angle of attack sensor over an angle of attack range from -10 deg to 110 deg. The sensor was mounted ahead of the wing on a 1/5 scale model of a general aviation airplane. It was shown that the flow correction was substantial, reaching about 15 deg at an angle of attack of 90 deg. The flow correction was found to increase as the sensor was moved closer to the wing or closer to the fuselage. The System measurements are made using optical transducers which are fixed to the case. Measurements made in this way are the equivalent of those obtained by placing three surface-normal displacement transducers at three positions on each blade of an operational rotor. M.M.M.

07 AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

For related information see also *20 Spacecraft Propulsion and Power, 28 Propellants and Fuels,* and *44 Energy Production and Conversion.*

N80-10205*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AEROPROPULSION 1979
1979 464 p Proceedings of conf. held at Cleveland, Ohio, 1-16 May 1979
(NASA-CP-2092; E-079) Avail: NTIS HC A20/MF A01 CSCL 21E

State of the art technology in aeronautical propulsion is assessed. Noise and air pollution control techniques, advances in supersonic propulsion for transport aircraft, and composite materials and structures for reliable engine components are covered along with engine design for improved fuel consumption. For individual titles, see N80-10206 through N80-10219.

N80-10206*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AIRCRAFT ENERGY EFFICIENCY (ACEE) STATUS REPORT
Donald L. Nored, James F. Dugan, Jr., Neal T. Saunders, and Joseph A. Ziemianski *In its* Aeropropulsion 1979 1979 p 1-58 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Fuel efficiency in aeronautics, for fuel conservation in general as well as for its effect on commercial aircraft operating economics is considered. Projects of the Aircraft Energy Efficiency Program related to propulsion are emphasized. These include: (1) engine component improvement, directed at performance improvement and engine diagnostics for prolonged service life; (2) energy efficient engine, directed at proving the technology base for the next generation of turbofan engines; and (3) advanced turboprop, directed at advancing the technology of turboprop powered aircraft to a point suitable for commercial airline service. Progress in these technology areas is reported. J.M.S.

N80-10207*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EMISSION REDUCTION
Donald A. Petrash, Larry A. Diehl, Robert E. Jones, and Edward J. Mularz *In its* Aeropropulsion 1979 1979 p 59-84 (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Control of the gaseous pollutant emissions of aircraft engines is considered in terms of the emission standards for six classes of aircraft engines. Emphasis is placed on combustor design concepts to significantly reduce emissions levels and lean-burning techniques to lower flame temperature, to reduce the oxides of nitrogen in the gaseous emissions. J.M.S.

N80-10208*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NOISE REDUCTION
Charles E. Feiler, John F. Groeneweg, Francis J. Montegani, John P. Raney (NASA. Langley Research Center), Edward J. Rice, and James R. Stone *In its* Aeropropulsion 1979 1979 p 85-128 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

The turbofan engine's noise-producing components are discussed in terms of efficient and economical noise reduction techniques that do not penalize the engine performance or weight significantly. Specific topics covered include fan noise, acoustic suppression, jet noise technology, combustor noise, and aircraft noise prediction. J.M.S.

N80-10209*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ALTERNATIVE JET AIRCRAFT FUELS
Jack Grobman *In its* Aeropropulsion 1979 1979 p 129-148 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Potential changes in jet aircraft fuel specifications due to shifts in supply and quality of refinery feedstocks are discussed with emphasis on the effects these changes would have on the performance and durability of aircraft engines and fuel systems. Combustion characteristics, fuel thermal stability, and fuel pumpability at low temperature are among the factors considered. Combustor and fuel system technology needs for broad specification fuels are reviewed including prevention of fuel system fouling and fuel system technology for fuels with higher freezing points. J.M.S.

N80-10210*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MATERIALS AND STRUCTURES TECHNOLOGY
Robert A. Signorelli, Thomas K. Glasgow, Gary R. Halford, and Stanley R. Levine *In its* Aeropropulsion 1979 1979 p 149-186 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Materials and structures performance limitations, particularly for the hot section of the engine in which these limitations limit the life of components, are considered. Failure modes for components such as blades, vanes, and combustors and how they are affected by the environment for such components are discussed. Methods used to improve the materials used for such components are: (1) application of directional structures to turbine components for high strength at high temperatures; (2) improved coatings to increase oxidation and corrosion resistance; (3) increase strength and stiffness with reduced weight by applying higher specific properties of composite materials; and (4) cost effective processing such as near net shape powder methods applied to disks. Life prediction techniques developed to predict component life accurately in advance of service and progress in improving the intermediate and cold section components of turbine engines are covered. J.M.S.

N80-10211*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTATIONAL FLUID MECHANICS OF INTERNAL FLOW
David N. Bowditch, William D. Mcnally, Bernhard H. Anderson, John J. Adamczyk, and Peter M. Sockol *In its* Aeropropulsion 1979 1979 p 187-230 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Major solution techniques for internal computational fluid mechanics are discussed and some examples are presented. The major steps involved in developing a large computer code are then discussed. R.E.S.

N80-10212*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TURBOMACHINERY TECHNOLOGY
Cavour H. Hauser, Jeffrey E. Haas (U.S. Army Res. and Technol. Labs., Cleveland, Ohio), Lonnie Reid, and Francis S. Stepka *In its* Aeropropulsion 1979 1979 p 231-272 (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

A technology assessment of turbomachinery is presented. The design of the fan, compressor, and turbine components for future advanced aircraft engines is discussed. Basic flow characteristics in compressors and turbines and the heat transfer phenomena in cooled turbines are also discussed. R.E.S.

N80-10213*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MECHANICAL COMPONENTS
William J. Anderson, Robert C. Bill, John J. Coy, and David Fleming *In its* Aeropropulsion 1979 1979 p 273-308 ref (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Research on bearings, gears, seals, and rotor dynamics (specifically high speed balancing and dampers) is presented. The research pertains to problems in both aircraft turbine engines and helicopter transmissions. R.E.S.

N80-10214*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INSTRUMENTATION TECHNOLOGY
William C. Nieberding, David R. Englund, Jr., and George E. Glawe *In its* Aeropropulsion 1979 1979 p 309-328 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Some of the efforts made in applying technologically new tools to today's propulsion measurement problems are described. They include: (1) a blade-tip clearance system; (2) a pulsed thermocouple system used to measure gas temperature with a thermocouple at temperatures above the melting point of the thermocouple; (3) an optical technique for measuring blade flutter; (4) a probe for dynamic flow and flow angle measurement; and (5) a laser anemometer system for rapidly mapping the flow profiles between the blades of a rotating compressor. R.E.S.

N80-10215*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONTROL TECHNOLOGY
John R. Szuch *In its* Aeropropulsion 1979 1979 p 329-344 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

An overview of engine control technology is presented with emphasis on gas turbine engine controls. The role of the government, and NASA in particular, in advancing this technology is discussed. R.E.S.

N80-10216*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUPERSONIC PROPULSION TECHNOLOGY
Albert G. Powers, Robert E. Coltrin, Leonard E. Stitt, Richard J. Weber, and John B. Whitlow, Jr. *In its* Aeropropulsion 1979 1979 p 345-386 (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Propulsion concepts for commercial supersonic transports are discussed. It is concluded that variable cycle engines, together with advanced supersonic inlets and low noise coannular nozzles, provide good operating performance for both supersonic and subsonic flight. In addition, they are reasonably quiet during takeoff and landing and have acceptable exhaust emissions. K.L.

N80-10217*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HYPERSONIC PROPULSION
H. Lee Beach, Jr. *In its* Aeropropulsion 1979 1979 p 387-408 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Research on hydrogen fueled scramjet engines for hypersonic flight is reviewed. Component developments, computational methods, and preliminary ground tests of subscale scramjet engine modules at Mach 4 and 7 are emphasized. Airframe integration, structures, and flow diagnostics are also discussed. It is shown that mixed-mode perpendicular and parallel fuel injection controls heat release over a wide Mach range and the fixed geometry inlet gives good performance over a wide range of Mach numbers. K.L.

N80-10218*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VERTICAL TAKEOFF AND LANDING (VTOL) PROPULSION TECHNOLOGY
Carl C. Ciepluch, John M. Abbott, Royce D. Moore, and James F. Sellers *In its* Aeropropulsion 1979 1979 p 409-444 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Propulsion problems and advanced technology requirements of VTOL aircraft are discussed. Specific topics covered include inlets with high angle of attack capability, rapid thrust modulation fans, and propulsion-system/aircraft-control integration. K.L.

N80-10219*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH-PERFORMANCE-VEHICLE TECHNOLOGY
Louis A. Povinelli *In its* Aeropropulsion 1979 1979 p 445-462 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Propulsion needs of high performance military aircraft are discussed. Inlet performance, nozzle performance and cooling, and afterburner performance are covered. It is concluded that nonaxisymmetric nozzles provide cleaner external lines and enhanced maneuverability, but the internal flows are more complex. Swirl afterburners show promise for enhanced performance in the high altitude, low Mach number region. K.L.

N80-11087*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INFLUENCE OF COOLANT TUBE CURVATURE ON FILM COOLING EFFECTIVENESS AS DETECTED BY INFRARED IMAGERY
S. Stephen Papell, Robert W. Graham, and Richard P. Cageao Washington Nov. 1979 18 p refs
(NASA-TP-1546; E-066) Avail: NTIS HC A02/MF A01 CSCL 21E

Thermal film cooling footprints observed by infrared imagery from straight, curved, and looped coolant tube geometries are compared. It was hypothesized that the differences in secondary flow and in the turbulence structure of flow through these three tubes should influence the mixing properties between the coolant and the main stream. A flow visualization tunnel, an infrared camera and detector, and a Hilsch tube were employed to test the hypothesis. A.W.H.

N80-12092*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ENGINE COMPONENT IMPROVEMENT PROGRAM: PERFORMANCE IMPROVEMENT
John E. McAulay 1979 17 p refs Presented at 18th Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980; sponsored by AIAA
(NASA-TM-79304; E-256) Avail: NTIS HC A02/MF A01 CSCL 21E

Fuel consumption of commercial aircraft is considered. Fuel saving and retention components for new production and retrofit of JT9D, JT8D, and CF6 engines are reviewed. The manner in which the performance improvement concepts were selected for development and a summary of the current status of each of the 16 selected concepts are discussed. R.C.T.

N80-13046*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLUTTER SPECTRAL MEASUREMENTS USING STATIONARY PRESSURE TRANSDUCERS
A. P. Kurkov 1980 15 p refs Presented at the 25th Annual Intern. Gas Turbine Conf. and the 22d Annual Fluids Eng. Conf., New Orleans, 9-13 Mar. 1980; sponsored by ASME
(NASA-TM-79293; E-237) Avail: NTIS HC A02/MF A01 CSCL 21E

Engine-order sampling was used to eliminate the integral harmonics from the flutter spectra corresponding to a case-mounted static pressure transducer. Using the optical displacement data, it was demonstrated that the blade-order sampling of pressure data may yield erroneous results due to the interference caused by blade vibration. Two methods are presented which effectively eliminate this interference yielding the blade-pressure-difference spectra. The phase difference between the differential-pressure and the displacement spectra was evaluated. Author

N80-13047*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ATOMIZING CHARACTERISTICS OF SWIRL CAN COMBUSTOR MODULES WITH SWIRL BLAST FUEL INJECTORS
Robert D. Ingebo 1980 11 p refs Presented at the 25th Annual Intern. Gas Turbine Conf., New Orleans, 9-13 Mar. 1980; sponsored by ASME
(NASA-TM-79297; E-248) Avail: NTIS HC A02/MF A01 CSCL 21E

Cold flow atomization tests of several different designs of swirl can combustor modules were conducted in a 7.6 cm diameter duct at airflow rates (per unit area) of 7.3 to 25.7 g/sq cm sec and water flow rates of 6.3 to 18.9 g/sec. The effect of air and water flow rates on the mean drop size of water sprays produced with the swirl blast fuel injectors were determined. Also, from these data it was possible to determine the effect of design modifications on the atomizing performance of various fuel injector and air swirler configurations. The trend in atomizing performance, as based on the mean drop size, was then compared with the trends in the production of nitrogen oxides obtained in combustion studues with the same swirl can combustors. It was found that the fuel injector design that gave the best combustor performance in terms of a low NOx emission index also gave the best atomizing performance as characterized by a spray of relatively small mean drop diameter. It was also demonstrated that at constant inlet air stream momentum the nitrogen oxides emission index was found to vary inversely with the square of the mean drop diameter of the spray produced by the different swirl blast fuel injectors. Test conditions were inlet air static pressures of 100,000 to 200,000 N/sq m at an inlet air temperature of 293 K. Author

N80-14121*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATIC TEST-STAND PERFORMANCE OF THE YF-102 TURBOFAN ENGINE WITH SEVERAL EXHAUST CONFIGURATIONS FOR THE QUIET SHORT-HAUL RESEARCH AIRCRAFT (QSRA)
Jack G. McArdle, Leonard Homyak, and Allan S. Moore Nov. 1979 62 p
(NASA-TP-1556; E-019) Avail: NTIS HC A04/MF A01 CSCL 21E

The performance of a YF-102 turbofan engine was measured in an outdoor test stand with a bellmouth inlet and seven exhaust-system configurations. The configurations consisted of three separate-flow systems of various fan and core nozzle sizes and four confluent-flow systems of various nozzle sizes and shapes. A computer program provided good estimates of the engine performance and of thrust at maximum rating for each exhaust configuration. The internal performance of two different-shaped core nozzles for confluent-flow configurations was determined to be satisfactory. Pressure and temperature surveys were made with a traversing probe in the exhaust-nozzle flow for some confluent-flow configurations. The survey data at the mixing plane, plus the measured flow rates, were used to calculate the static-pressure variation along the exhaust nozzle length. The computed pressures compared well with experimental wall static-pressure data. External-flow surveys were made, for some confluent-flow configurations, with a large fixed rake at various locations in the exhaust plume. A.R.H.

N80-14123*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DYNAMIC RESPONSE OF A MACH 2.5 AXISYMMETRIC INLET AND TURBOJET ENGINE WITH A POPPET-VALUE CONTROLLED INLET STABILITY BYPASS SYSTEM WHEN SUBJECTED TO INTERNAL AND EXTERNAL AIRFLOW TRANSIENTS
Bobby W. Sanders Washington Jan. 1980 102 p refs
(NASA-TP-1531; E-9467) Avail: NTIS HC A06/MF A01 CSCL 21E

The throat of a Mach 2.5 inlet that was attached to a turbojet engine was fitted with a poppet-valve-controlled stability bypass system that was designed to provide a large, stable airflow range. Propulsion system response and stability bypass performance were determined for several transient airflow disturbances, both internal and external. Internal airflow disturbances included reductions in overboard bypass airflow, power lever angle, and primary-nozzle area as well as compressor stall. For reference, data are also included for a conventional, fixed-exit bleed system. The poppet valves greatly increased inlet stability and had no adverse effects on propulsion system performance. Limited unstarted-inlet bleed performance data are presented. Author

N80-14124*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TURBOJET-EXHAUST-NOZZLE SECONDARY-AIRFLOW PUMPING AS AN EXIT CONTROL OF AN INLET-STABILITY BYPASS SYSTEM FOR A MACH 2.5 AXISYMMETRIC MIXED-COMPRESSION INLET
Bobby W. Sanders Jan. 1980 82 p refs
(NASA-TP-1532; E-9468) Avail: NTIS HC A05/MF A01 CSCL 21E

The throat of a Mach 2.5 inlet that was attached to a turbojet engine was fitted with large, porous bleed areas to provide a stability bypass system that would allow a large, stable airflow range. Exhaust-nozzle, secondary-airflow pumping was used as the exit control for the stability bypass airflow. Propulsion system response and stability bypass performance were obtained for several transient airflow disturbances, both internal and external. Internal airflow disturbances included reductions in overboard bypass airflow, power lever angle, and primary-nozzle area, as well as compressor stall. Nozzle secondary pumping as a stability bypass exit control can provide the inlet with a large stability margin with no adverse effects on propulsion system performance. Author

N80-14125*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF DEGREE OF FUEL VAPORIZATION UPON EMISSIONS FOR A PREMIXED PARTIALLY VAPORIZED COMBUSTION SYSTEM
Larry P. Cooper Jan. 1980 25 p refs
(NASA-TP-1582; E-010) Avail: NTIS HC A02/MF A01 CSCL 21E

An experimental and analytical study of the combustion of partially vaporized fuel-air mixtures was performed to assess the impact of the degree of fuel vaporization upon emissions for a premixing-prevaporizing flametube combustor. Data collected in this study showed near linear increases in nitric oxide emissions with decreasing vaporization at equivalence ratios of 0.6. For equivalence ratios of 0.72, the degree of vaporization had very little impact on nitric oxide emissions. A simple mechanism which accounts for the combustion of liquid droplets in partially vaporized mixtures was found to agree with the measured results with fair accuracy with respect to both trends and magnitudes. Author

N80-14126*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA BROAD-SPECIFICATION FUELS COMBUSTION TECHNOLOGY PROGRAM: STATUS AND DESCRIPTION
James S. Fear 1979 14 p refs Presented at 25th Ann. Intern. Gas Turbine Conf., New Orleans, 9-13 Mar. 1980; sponsored by Am. Soc. of Mech. Engr.
(NASA-TM-79315; E-272) Avail: NTIS HC A02/MF A01 CSCL 21E

The program presented is a contracted effort to evolve and demonstrate the technology required to utilize broad-specification fuels in current and next generation commercial Conventional

Takeoff and Landing aircraft engines, and to verify this technology in full-scale engine tests in 1983. The program consists of three phases: Combustor Concept Screening, Combustor Optimization Testing, and Engine Verification Testing. The development and screening of the combustion system designs for the CF6-80 engine and the JT9D-7 engine, respectively, in high-pressure sector test rigs are reported. M.M.M.

N80-15126*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LASER-OPTICAL BLADE TIP CLEARANCE MEASUREMENT SYSTEM
John P. Barranger and M. John Ford (Pratt and Whitney Aircraft Group, West Palm Beach, Fla.) 13 Mar. 1979 10 p refs Proposed for presentation at 25th Ann. Intern. Gas Turbine Conf. and the 22d Ann. Fluids Engr. Conf., New Orleans, 9-13 Mar. 1980; sponsored by Am. Soc. of Mech. Engr.
(NASA-TM-81376) Avail: NTIS HC A02/MF A01 CSCL 21E

A laser-optical measurement system was developed to measure single blade tip clearances and average blade tip clearances between a rotor and its gas path seal in rotating component rigs and complete engines. The system is applicable to fan, compressor and turbine blade tip clearance measurements. The engine mounted probe is particularly suitable for operation in the extreme turbine environment. The measurement system consists of an optical subsystem, an electronic subsystem and a computing and graphic terminal. Bench tests and environmental tests were conducted to confirm operation at temperatures, pressures, and vibration levels typically encountered in an operating gas turbine engine. DOE

N80-15127*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
QUIET POWERED-LIFT PROPULSION
1979 426 p refs Conf. held at Cleveland, Ohio, 14-15 Nov. 1978
(NASA-CP-2077; E-9906) Avail: NTIS HC A19/MF A01 CSCL 21E

Latest results of programs exploring new propulsion technology for powered-lift aircraft systems are presented. Topics discussed include results from the 'quiet clean short-haul experimental engine' program and progress reports on the 'quiet short-haul research aircraft' and 'tilt-rotor research aircraft' programs. In addition to these NASA programs, the Air Force AMST YC 14 and YC 15 programs were reviewed. R.E.S.

N80-15128*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DIRECT INTEGRATION OF TRANSIENT ROTOR DYNAMICS
Albert F. Kascak Washington Jan. 1980 23 p refs
(NASA-TP-1597; AVRADCOM-TR-79-42; E-101) Avail: NTIS HC A02/MF A01 CSCL 21E

An implicit method was developed for integrating the equations of motion for a lumped mass model of a rotor dynamics system. As an aside, a closed form solution to the short bearing theory was also developed for a damper with arbitrary motion. The major conclusions are that the method is numerically stable and that the computation time is proportional to the number of elements in the rotor dynamics model rather than to the cube of the number. This computer code allowed the simulation of a complex rotor bearing system experiencing nonlinear transient motion and displayed the vast amount of results in an easily understood motion picture format - a 10 minute, 16 millimeter, color, sound motion picture supplement. An example problem with 19 mass elements in the rotor dynamics model took 0.7 second of central processing unit time per time step on an IBM 360-67 computer in a time sharing mode. R.C.T.

N80-15132*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTER SIMULATION OF ENGINE SYSTEMS
L. H. Fishback 1980 26 p refs Presented at the 18th Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980; sponsored by AIAA
(NASA-TM-79290; E-234) Avail: NTIS HC A03/MF A01 CSCL 21E

The use of computerized simulations of the steady state and transient performance of jet engines throughout the flight regime is discussed. In addition, installation effects on thrust and specific fuel consumption is accounted for as well as engine weight, dimensions and cost. The availability throughout the government and industry of analytical methods for calculating these quantities are pointed out. M.M.M.

N80-15133*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPACT OF NEW INSTRUMENTATION ON ADVANCED TURBINE RESEARCH
Robert W. Graham Mar. 1980 25 p refs Proposed for presentation at the 1980 Spring Ann. Meeting, New Orleans, 5-13 Mar. 1980; sponsored by ASME
(NASA-TM-79301; E-251) Avail: NTIS HC A02/MF A01 CSCL 21E

A description is presented of an orderly test program that progresses from the simplest stationary geometry to the more complex, three dimensional, rotating turbine stage. The instrumentation requirements for this evolution of testing are described. The heat transfer instrumentation is emphasized. Recent progress made in devising new measurement techniques has greatly improved the development and confirmation of more accurate analytical methods for the prediction of turbine performance and heat transfer. However, there remain challenging requirements for novel measurement techniques that could advance the future research to be done in rotating blade rows of turbomachines. M.M.M.

N80-15134*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN ANALYTICAL AND EXPERIMENTAL STUDY OF A SHORT S-SHAPED SUBSONIC DIFFUSER OF A SUPERSONIC INLET
Harvey E. Neumann, Louis A. Povinelli, and Robert E. Coltrin 1980 14 p refs Presented at 18th Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan 1980; sponsored by AIAA
(NASA-TM-81406; E-320) Avail: NTIS HC A02/MF A01 CSCL 21E

A subscale HiMAT forebody and inlet was investigated over a range of Mach numbers to 1.4. The inlet exhibited a transitory separation within the diffuser but steady state data indicated reattachment at the diffuser exit. A finite difference procedure for turbulent compressible flow in axisymmetric ducts was used to successfully model the HiMAT duct flow. The analysis technique was further used to estimate the initiation of separation and delineate the steady and unsteady flow regimes in similar S-shaped ducts. R.C.T.

N80-17071*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AERODYNAMIC PERFORMANCES OF THREE FAN STATOR DESIGNS OPERATING WITH ROTOR HAVING TIP SPEED OF 337 METERS PER SECOND AND PRESSURE RATIO OF 1.54. 1: EXPERIMENTAL PERFORMANCE
Thomas F. Gelder Feb. 1980 108 p refs
(NASA-TP-1610; E-136) Avail: NTIS HC A06/MF A01 CSCL 21E

The aerodynamic performances of four stator-blade rows are presented and evaluated. The aerodynamic designs of two of these stators were compromised to reduce noise, a third design was not. On a calculated operating line passing through the design point pressure ratio, the best stator had overall pressure-ratio and efficiency decrements of 0.031 and 0.044, respectively, providing a stage pressure ratio of 1.483 and efficiency of 0.865. The other stators showed some correctable deficiencies due partly to the design compromises for noise. In the end-wall regions blade-element losses were significantly less for the shortest chord studied. Author

N80-18039* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

METHOD AND APPARATUS FOR RAPID THRUST INCREASES IN A TURBOFAN ENGINE Patent

Jack E. Cornett (GE, Cincinnati, Ohio), Ralph C. Corley (GE, Cincinnati, Ohio), Thomas O. Fraley (GE, Cincinnati, Ohio), and Andrew A. Saunders, Jr., inventors (to NASA) (GE, Cincinnati, Ohio) Issued 22 Jan. 1980 9 p Filed 9 Dec. 1977 Sponsored by NASA
(NASA-Case-LEW-12971-1; US-Patent-4,184,327 ; US-Patent-Appl-SN-858936; US-Patent-Class-60-240; US-Patent-Class-60-39.03; US-Patent-Class-60-39.27) Avail: US Patent and Trademark Office CSCL 21E

Upon a landing approach, the normal compressor stator schedule of a fan speed controlled turbofan engine is temporarily varied to substantially close the stators to thereby increase the fuel flow and compressor speed in order to maintain fan speed and thrust. This running of the compressor at an off-design speed substantially reduces the time required to subsequently advance the engine speed to the takeoff thrust level by advancing the throttle and opening the compressor stators.
Official Gazette of the U.S. Patent and Trademark Office

N80-18043*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AEROPROPULSION IN YEAR 2000

Richard J. Weber 1980 18 p refs Proposed for presentation at Global Technol. 2000, the 1980 Intern. Meeting of the Am. Inst. of Aeron. and Astronautics, Baltimore, 5-11 May 1980
21A

A sampling of probable future engine types, such as convertible engines for helicopters, turboprops for fuel-conservative airliners, and variable-cycle engines for supersonic transports are presented. Related technology improvements in propellers, materials, noise suppression, etc. are reviewed R.E.S.

N80-19110*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY STUDY OF VTO THRUST REQUIREMENTS FOR A V/STOL AIRCRAFT WITH LIFT PLUS LIFT/CRUISE PROPULSION

George E. Turney and John L. Allen Feb. 1980 23 p refs
(NASA-TM-81429; E-351) Avail: NTIS HC A02/MF A01 CSCL 21E

A preliminary assessment was made of the VTO thrust requirements for a supersonic (Type B) aircraft with a Lift plus Lift/Cruise propulsion system. A baseline aircraft with a takeoff gross weight (TOGW) of 13 608 kg (30,000 lb) was assumed. Pitch, roll, and yaw control thrusts (i.e., the thrusts needed for aircraft attitude control in the flight hover mode) were estimated based on a specified set of maneuver acceleration requirements for V/STOL aircraft. Other effects (such as installation losses, suckdown, reingestion, etc.), which add to the thrust requirements for VTO were also estimated. For the baseline aircraft, the excess thrust required for attitude control of the aircraft during VTO and flight hover was estimated to range from 36.9 to 50.9 percent of the TOGW. It was concluded that the total thrust requirements for the aircraft/propulsion system are large and significant. In order to achieve the performance expected of this aircraft/propulsion system, reductions must be made in the excess thrust requirements. J.M.S.

N80-20272*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF WATER INJECTION AND OFF SCHEDULING OF VARIABLE INLET GUIDE VANES, GAS GENERATOR SPEED AND POWER TURBINE NOZZLE ANGLE ON THE PERFORMANCE OF AN AUTOMOTIVE GAS TURBINE ENGINE

Edward L. Warren Mar. 1980 35 p
(Contract EC-77-A-31-1040)
(NASA-TM-81415; E-333; DOE/NASA/1040-80/10) Avail: NTIS HC A03/MF A01 CSCL 21E

The Chrysler/ERDA baseline automotive gas turbine engine was used to experimentally determine the power augmentation and emissions reductions achieved by the effect of variable compressor and power engine geometry, water injection downstream of the compressor, and increases in gas generator speed. Results were dependent on the mode of variable geometry utilization. Over 20 percent increase in power was accompanied by over 5 percent reduction in SFC. A fuel economy improvement of at least 6 percent was estimated for a vehicle with a 75 kW (100 hp) engine which could be augmented to 89 kW (120 hp) relative to an 89 Kw (120 hp) unaugmented engine. Author

N80-20274*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

JT9D-7A (SP) JET ENGINE PERFORMANCE DETERIORATION TRENDS

G. Paul Richter, W. J. Olsson, and N. B. Andersen 1980 24 p ref Presented at the Intern. Aircraft Maintenance Eng. Exhibition and Conf., Dallas, 8-10 Apr. 1980; sponsored by Hamilton Burr Publishing Co. Prepared in cooperation with Pratt and Whitney Aircraft Group, East Hartford, Conn. and Pan American World Airways, Inc., Jamaica, N.Y.
(NASA-TM-81459; E-388) Avail: NTIS HC A02/MF A01 CSCL 21E

The levels, trends, and causes of engine performance deterioration were investigated. A series of installed engine calibrations (both on-the-ground and in-flight) were performed on two new Pan American World Airways 747 SP aircraft. The performance data gathered covered from before the first flight through approximately 1000 flight cycles and 6900 flight hours. To accomplish the calibrations a special instrumentation system for ground testing of installed engines over a broad power range was used along with performing concurrent in-flight engine calibrations under revenue service conditions. Results of the analysis of the data, which provide a better understanding of short and long term performance deterioration of both engines and modules are presented. J.M.S.

N80-20275*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPTIMUM SUBSONIC, HIGH-ANGLE-OF-ATTACK NACELLES

Roger W. Luidens, Norbert O. Stockman, and James H. Diedrich [1979] 20 p refs Prepared for the 12th Congr. of the Intern. Council of the Aeron. Sci., Munich, 13-17 Oct. 1980 and the 1980 Aerospace Congr. and Exposition, Los Angeles, 13-16 Oct. 1980; sponsored by the Soc. of Automotive Engr.
(NASA-TM-81491; E-406) Avail: NTIS HC A02/MF A01 CSCL 21E

The optimum design of nacelles that operate over a wide range of aerodynamic conditions and their inlets is described. For low speed operation the optimum internal surface velocity distributions and skin friction distributions are described for three categories of inlets; those with BLC, and those with blow in door slots and retractable slats. At cruise speed the effect of factors that reduce the nacelle external surface area and the local skin friction is illustrated. These factors are cruise Mach number, inlet throat size, fan-face Mach number, and nacelle contour. The interrelation of these cruise speed factors with the design requirements for good low speed performance is discussed. J.M.S.

N80-21323*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL EVALUATION OF A SPINNING-MODE ACOUSTIC-TREATMENT DESIGN CONCEPT FOR AIRCRAFT INLETS

Laurence J. Heidelberg, Edward J. Rice, and Leonard Homyak Apr. 1980 29 p refs
(NASA-TP-1613; E-185) Avail: NTIS HC A03/MF A01 CSCL 21E

An aircraft-inlet noise suppressor method based on mode cutoff ratio was qualitatively checked by testing a series of liners on a YF-102 turbofan engine. Far-field directivity of the blade passing frequency was used extensively to evaluate the results. The trends and observations of the test data lend much qualitative support to the design method. The best of the BPF liners attained a suppression at design frequency of 19 dB per unit length-diameter ratio. The best multiple-pure-tone linear attained a remarkable suppression of 65.6 bB per unit length-diameter ratio. Author

N80-21324*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AERODYNAMIC PERFORMANCES OF THREE FAN STATOR DESIGNS OPERATING WITH ROTOR HAVING TIP SPEED OF 337 METERS PER SECOND AND PRESSURE RATIO OF 1.54. RELATION OF ANALYTICAL CODE CALCULATIONS TO EXPERIMENTAL PERFORMANCE
Thomas F. Gelder, James F. Schmidt, and Genevieve M. Esgar Apr. 1980 53 p refs
(NASA-TP-1614; E-137) Avail: NTIS HC A04/MF A01 CSCL 21E

A hub-to-shroud and a blade-to-blade internal-flow analysis code, both inviscid and basically subsonic, were used to calculate the flow parameters within four stator-blade rows. The produced ratios of maximum suction-surface velocity to trailing-edge velocity correlated well in the midspan region, with the measured total-parameters over the minimum-loss to near stall operating range for all stators and speeds studied. The potential benefits of a blade designed with the aid of these flow analysis codes are illustrated by a proposed redesign of one of the four stators studied. An overall efficiency improvement of 1.6 points above the peak measured for that stator is predicted for the redesign. Author

N80-21325*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF SINGLE-STAGE AXIAL-FLOW TRANSONIC COMPRESSOR WITH ROTOR AND STATOR ASPECT RATIOS OF 1.19 AND 1.26 RESPECTIVELY, AND WITH DESIGN PRESSURE RATIO OF 2.05
Royce D. Moore and Lonnie Reid Washington Apr. 1980 103 p
(NASA-TP-1659; E-138) Avail: NTIS HC A06/MF A01 CSCL 21E

The overall and blade-element performances of a low-aspect-ratio transonic compressor stage are presented over the stable operating flow range for speeds from 50 to 100 percent of design. At design speed the rotor and stage achieved peak efficiencies of 0.876 and 0.840 at pressure ratios of 2.056 and 2.000, respectively. The stage stall margin at design speed was 10 percent. Author

N80-21326*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF UNCERTAINTIES IN TURBINE METAL TEMPERATURE PREDICTIONS
Francis S. Stepka Washington Apr. 1980 19 p refs
(NASA-TP-1593; E-228) Avail: NTIS HC A02/MF A01 CSCL 21E

An analysis was conducted to examine the extent to which various factors influence the accuracy of analytically predicting turbine blade metal temperatures and to determine the uncertainties in these predictions for several accuracies of the influence factors. The advanced turbofan engine gas conditions of 1700 K and 40 atmospheres were considered along with those of a highly instrumented high temperature turbine test rig and a low temperature turbine rig that simulated the engine conditions. The analysis showed that the uncertainty in analytically predicting local blade temperature was as much as 98 K, or 7.6 percent of the metal absolute temperature, with current knowledge of the influence factors. The expected reductions in uncertainties in the influence factors with additional knowledge and tests should reduce the uncertainty in predicting blade metal temperature to 28 K, or 2.1 percent of the metal absolute temperature. Author

N80-21333*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
STEADY-STATE PERFORMANCE OF J85-21 COMPRESSOR AT 100 PERCENT OF DESIGN SPEED WITH AND WITHOUT INTERSTAGE RAKE BLOCKAGE
Roger A. Werner Mar. 1980 36 p refs
(NASA-TM-81451; E-377) Avail: NTIS HC A03/MF A01 CSCL 21E

Internal compressor instrumentation blockage effects on steady state J85-21 compressor performance at 100 percent of design speed are determined. The blockage was generated by instrumented vanes for the first three compressor stages and by removal rakes for stages 4 to 9. Individual flow passage blockages ranged up to 4.5 percent with the instrumented vanes and up to 22 percent with the removable interstage rakes. At a Reynolds number index of 1.0, pressure ratio and airflow remained unchanged with insertion of the interstage rakes, but efficiency dropped 0.3 percentage point. Compressor exit profiles, compressor stage static pressure rise coefficients, turbine exit temperature, and fuel flow are also presented. J.M.S.

N80-22327*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GENERAL AVIATION PROPULSION
Mar 1980 437 p refs Conf held in Cleveland, 28-29 Nov. 1979
(NASA-CP-2126, E-310) Avail NTIS HC A19/MF A01 CSCL 21E

Programs exploring and demonstrating new technologies in general aviation propulsion are considered. These programs are the quiet, clean, general aviation turbofan (QCGAT) program, the general aviation turbine engine (GATE) study program, the general aviation propeller technology program; and the advanced rotary, diesel, and reciprocating engine programs. For individual titles, see N80-22328 through N80-22348.

N80-22334*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUMMARY OF NASA QCGAT PROGRAM
Gilbert K. Sievers *In its* Gen. Aviation Propulsion Mar. 1980 p 189-193 (For primary document see N80-22327 13-07)
Avail: NTIS HC A19/MF A01 CSCL 21E

The application of large turbofan engine technology to small general aviation turbofan engines to achieve low noise, low emissions, and acceptable fuel consumption is described. R.E.S.

N80-22335*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NEW OPPORTUNITIES FOR FUTURE, SMALL, GENERAL-AVIATION TURBINE ENGINES (GATE)
William C. Strack *In its* Gen. Aviation Propulsion Mar. 1980 p 195-219 refs (For primary document see N80-22327 13-07)
Avail: NTIS HC A19/MF A01 CSCL 21E

The results of four independent contracted studies to explore the opportunities for future small turbine engines are summarized in a composite overview. Candidate advanced technologies are screened, various cycles and staging arrangements are parametrically evaluated, and optimum conceptual engines are identified for a range of 300 to 600 horsepower applications. Engine improvements of 20 percent in specific fuel consumption and 40 percent in engine cost were forecast using high risk technologies that could be technically demonstrated by 1988. The ensuing economic benefits are in the neighborhood of 20 to 30 percent for twin-engine aircraft currently powered by piston engines. Author

N80-22336*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN OVERVIEW OF NASA RESEARCH ON POSITIVE DISPLACEMENT GENERAL-AVIATION ENGINES
Erwin E. Kempke, Jr. *In its* Gen. Aviation Propulsion Mar. 1980 p 227-229 (For primary document see N80-22327 13-07)
Avail: NTIS HC A19/MF A01 CSCL 21E

The research and technology program related to improved and advanced general aviation engines is described. Current research is directed at the near-term improvement of conventional air-cooled spark-ignition piston engines and at future alternative engine systems based on all-new spark-ignition piston engines, lightweight diesels, and rotary combustion engines that show potential for meeting program goals in the midterm and long-term future. The conventional piston engine activities involve efforts on applying existing technology to improve fuel economy, investigation of key processes to permit leaner operation and reduce drag, and the development of cost effective technology to permit flight at high-altitudes where fuel economy and safety are improved. The advanced engine concepts activities include engine conceptual design studies and enabling technology efforts on the critical or key technology items. R.E.S.

N80-22340*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

POSITIVE DISPLACEMENT TYPE GENERAL-AVIATION ENGINES: SUMMARY AND CONCLUDING REMARKS

Erwin E. Kempke, Jr. *In its* Gen. Aviation Propulsion Mar. 1980 p 313-314 (For primary document see N80-22327 13-07) Avail: NTIS HC A19/MF A01 CSCL 21E

The activities of programs investigating various aspects of aircraft internal combustion engines are briefly described including developments in fuel injection technology, cooling systems and drag reduction, turbocharger technology, and stratified-charge rotary engines. M.G.

N80-22341*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASA PROPELLER TECHNOLOGY PROGRAM

Daniel C. Mikkelson *In its* Gen. Aviation Propulsion Mar. 1980 p 315-325 refs (For primary document see N80-22327 13-07) Avail: NTIS HC A19/MF A01 CSCL 21E

A program on propeller technology applicable to both low and high speed general aviation aircraft is summarized, and the overall program objectives and approach are outlined. M.G.

N80-22344*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HIGH-SPEED-PROPELLER WIND-TUNNEL AEROACOUSTIC RESULTS

Robert J. Jeracki and James H. Dittmar *In its* Gen. Aviation Propulsion Mar. 1980 p 361-374 refs (For primary document see N80-22327 13-07)

Avail: NTIS HC A19/MF A01 CSCL 21E

Some aerodynamic concepts are presented together with an explanation of how these concepts are applied to advanced propeller design. The unique features of this propulsion system are addressed with emphasis on the design concepts being considered for the high speed turboprop. More particular emphasis is given to the blade sweep, long blade chords, and the large number of blades. R.C.T.

N80-22345*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ADVANCED PROPELLER AERODYNAMIC ANALYSIS

Lawrence J. Bober *In its* Gen. Aviation Propulsion Mar. 1980 p 375-385 refs (For primary document see N80-22327 13-07) Avail: NTIS HC A19/MF A01 CSCL 21E

The analytical approaches as well as the capabilities of three advanced analyses for predicting propeller aerodynamic performance are presented. It is shown that two of these analyses use a lifting line representation for the propeller blades, and the third uses a lifting surface representation. R.C.T.

N80-2?34?*# National Aeronautics and Space Administration. Lewis ? ?ch Center, Cleveland, Ohio.

EFFECT ? ?HERMAL CYCLING ON ZrO2-Y2O3 THERMAL BARRIER ?ATINGS

G. McDonald and Robert C. Hendricks 1980 10 p refs Presented at the Intern. Conf. on Met. Coatings, San Diego, Calif., 21-25 Apr. 1980; sponsored by the Am. Vacuum Soc.

(NASA-TM-81480; E-416) Avail: NTIS HC A02/MF A01 CSCL 21E

A study was made of the comparative life of plasma sprayed ZrO2-Y2O3 thermal barrier coatings on NiCrAlY bond coats on Rene 41 in short (4 min) and long (57 min) thermal cycles to 1040 C in a 0.3 Mach flame. Short cycles greatly reduced the life of the ceramic coating in terms of time at temperature as compared to longer cycles. Appearance of the failed coating indicated compressive failure. Failure occurred at the bond coat-ceramic coat junction. At heating rates greater than 550 kw/sq m, the calculated coating detachment stress was in the range of literature values of coating adhesive/cohesive strength. Methods are discussed for decreasing the effect of high heating rate by avoiding compressive stress. Author

N80-22350*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY STUDY OF ADVANCED TURBOPROP AND TURBOSHAFT ENGINES FOR LIGHT AIRCRAFT

G. Knip, R. M. Plencner, and J. D. Eisenberg Apr. 1980 62 p refs

(NASA-TM-81467; E-397) Avail: NTIS HC A04/MF A01 CSCL 21E

The effects of engine configuration, advanced component technology, compressor pressure ratio and turbine rotor-inlet temperature on such figures of merit as vehicle gross weight, mission fuel, aircraft acquisition cost, operating, cost and life cycle cost are determined for three fixed- and two rotary-wing aircraft. Compared with a current production turboprop, an advanced technology (1988) engine results in a 23 percent decrease in specific fuel consumption. Depending on the figure of merit and the mission, turbine engine cost reductions required to achieve aircraft cost parity with a current spark ignition reciprocating (SIR) engine vary from 0 to 60 percent and from 6 to 74 percent with a hypothetical advanced SIR engine. Compared with a hypothetical turboshaft using currently available technology (1978), an advanced technology (1988) engine installed in a light twin-engine helicopter results in a 16 percent reduction in mission fuel and about 11 percent in most of the other figures of merit. A.R.H.

N80-23310*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SIGNIFICANCE OF THERMAL CONTACT RESISTANCE IN TWO-LAYER THERMAL-BARRIER-COATED TURBINE VANES

Curt H. Liebert and Raymond E. Gaugler 1980 ?1 p refs Presented at the Intern Conf. on Met. Coatings, San Diego, Calif., 21-25 Apr. 1980; sponsored by the Am. Vacuum Soc. (NASA-TM-81483; E-420) Avail: NTIS HC A02/MF A01 CSCL 21E

The importance of thermal contact resistance between layers in heat transfer through two layer, plasma sprayed, thermal barrier coatings applied to turbine vanes was investigated. Results obtained with a system of NiCrAlY bond and yttria stabilized zirconia ceramic show that thermal contact resistance between layers is negligible. These results also verfied other studies which showed that thermal contact resistance is negligible for a different coating system of NiCr bond calcia stabilized zirconia ceramic. The zirconia stabilized ceramic thermal conductivity data scatter presented in the literature is ±20 to -10 percent about a curve fit of the data. More accurate predictions of heat transfer and metal wall temperatures are obtained when the thermal conductivity values are used at the ±20 percent level. E.D.K.

N80-23313*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DEVELOPMENT OF IMPROVED-DURABILITY PLASMA SPRAYED CERAMIC COATINGS FOR GAS TURBINE ENGINES

Irving E. Sumner and Duane L. Ruckle (Pratt and Whitney Aircraft,

East Hartford, Conn.) 1980 25 p refs Proposed for presentation at the 16th Joint Propulsion Conf., Hartford, 30 Jun. - 2 Jul. 1980; sponsored by AIAA, ASME and SAE
(NASA-TM-81512; E-451) Avail: NTIS HC A02/MF A01 CSCL 21E

As part of a NASA program to reduce fuel consumption of current commercial aircraft engines, methods were investigated for improving the durability of plasma sprayed ceramic coatings for use on vane platforms in the JT9D turbofan engine. Increased durability concepts under evaluation include use of improved strain tolerant microstructures and control of the substrate temperature during coating application. Initial burner rig tests conducted at temperatures of 1010 C (1850 F) indicate that improvements in cyclic life greater than 20:1 over previous ceramic coating systems were achieved. Three plasma sprayed coating systems applied to first stage vane platforms in the high pressure turbine were subjected to a 100-cycle JT9D engine endurance test with only minor damage occurring to the coatings. A.R.H.

N80-23314*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OSCEE FAN EXHAUST BULK ABSORBER TREATMENT EVALUATION
H. E. Bloomer and Nick E. Samanich 1980 20 p refs Presented at 6th Aeroacoustics Conf., 4-6 June 1980; sponsored by AIAA
(NASA-TM-81498; E-435) Avail: NTIS HC A02/MF A01 CSCL 21E

The acoustic suppression capability of bulk absorber material designed for use in the fan exhaust duct walls of the quiet clean short haul experiment engine (OCSEE UTW) was evaluated. The acoustic suppression to the original design for the engine fan duct which consisted of phased single degree-of-freedom wall treatment was tested with a splitter and also with the splitter removed. Peak suppression was about as predicted with the bulk absorber configuration, however, the broadband characteristics were not attained. Post test inspection revealed surface oil contamination on the bulk material which could have caused the loss in bandwidth suppression. R.C.T.

N80-24315*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
QCSEE UTW ENGINE POWERED-LIFT ACOUSTIC PERFORMANCE
I. J. Loeffler, N. E. Samanich, and H. E. Bloomer 1980 35 p refs Presented at the 6th Aeroacoustics Conf., Hartford, 4-6 Jun. 1980; sponsored by the AIAA
(NASA-TM-81504; E-442) Avail: NTIS HC A03/MF A01 CSCL 21E

Powered-lift acoustic test of the Quiet Clean Short Haul Experimental Engine (QCSEE) under the wing (UTW) engine are reported. Propulsion systems for two powered-lift concepts were designed, fabricated, and tested. In addition to low noise features, the designs included composite structures, gear-driven fans, digital control, and a variable pitch fan (UTW). The UTW engine was tested in a static ground test facility with wing and flap segments to simulate installation on a short haul transport aircraft of the future. Powered-lift acoustic performance of the UTW engine is compared with that of the previously tested and reported QCSEE over-the-wing (OTW) engine. Both engines were slightly above the noise goal but were significantly below current FAA and modern wide-body jet transport levels. The UTW system in the powered-lift mode was penalized by reflected engine noise from the wing and flap system, while the OTW system was benefitted by a wing noise shielding effect. J.M.S.

N80-24314*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARISON OF SEVERAL INFLOW CONTROL DEVICES FOR FLIGHT SIMULATION OF FAN TONE NOISE USING A JT15D-1 ENGINE
J. G. McArdle, W. L. Jones, L. J. Heidelberg, and L. Homyak 1980 45 p refs Presented at the 6th Aeroacoustics Conf., Hartford, 4-6 Jun. 1980; sponsored by AIAA
(NASA-TM-81505; E-443) Avail: NTIS HC A02/MF A01 CSCL 21E

To enable accurate simulation of in-flight fan tone noise during ground static tests, four devices intended to reduce inflow disturbances and turbulence were tested with a JT15D-1 turbofan engine. These inflow control devices (ICD's) consisted of honeycomb/screen structures mounted over the engine inlet. The ICD's ranged from 1.6 to 4 fan diameters in size, and differed in shape and fabrication method. All the ICD's significantly reduced the BPF tone in the far-field directivity patterns, but the smallest ICD's apparently introduced propagating modes which could be recognized by additional lobes in the speeds; at supersonic fan tip speed the smallest ICD's had some measurable loss, but the largest had no loss. Data from a typical transducer show that the unsteady inflow distortion modes (turbulence) were eliminated or significantly reduced when either of the ICD's was installed. However, some steady inflow distortion modes remained. A.R.H.

N80-24316*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADVANCED COMPONENT TECHNOLOGIES FOR ENERGY-EFFICIENT TURBOFAN ENGINES
Neal T. Saunders 1980 19 p refs Presented at the 16th Joint Propulsion Conf., Hartford, 30 Jun. - 2 Jul. 1980; cosponsored by AIAA, ASME and SAE
(NASA-TM-81507; E-445) Avail: NTIS HC A02/MF A01 CSCL 21E

A cooperative government-industry effort, the Energy Efficient Engine Project, to develop the advanced technology base for future commercial development of a new generation of more fuel conservative turbofan engines for airline use is described. Engine configurations that are dependent upon technology advances in each major engine component are defined and current design and development of the advanced components are included. J.M.S.

N80-25337*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN AND COLD-AIR TEST OF SINGLE-STAGE UNCOOLED TURBINE WITH HIGH WORK OUTPUT
Thomas P. Moffitt, Edward M. Szanca, Warren J. Whitney, and Frank P. Behning Jun. 1980 18 p refs
(NASA-TP-1680; E-316) Avail: NTIS HC A02/MF A01 CSCL 21E

A solid version of a 50.8 cm single stage core turbine designed for high temperature was tested in cold air over a range of speed and pressure ratio. Design equivalent specific work was 76.84 J/g at an engine turbine tip speed of 579.1 m/sec. At design speed and pressure ratio, the total efficiency of the turbine was 88.6 percent, which is 0.6 point lower than the design value of 89.2 percent. The corresponding mass flow was 4.0 percent greater than design. Author

N80-25338*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COLD-AIR INVESTIGATION OF A 4 1/2 STAGE TURBINE WITH STAGE-LOADING FACTOR OF 4.66 AND HIGH SPECIFIC WORK OUTPUT. 2: STAGE GROUP PERFORMANCE
Warren J. Whitney, Frank P. Behning, Thomas P. Moffitt, and Glen M. Hotz Jun. 1980 16 p refs
(NASA-TP-1688; E-315) Avail: NTIS HC A02/MF A01 CSCL 21E

The stage group performance of a 4 1/2 stage turbine with an average stage loading factor of 4.66 and high specific work output was determined in cold air at design equivalent speed. The four stage turbine configuration produced design equivalent work output with an efficiency of 0.856; a barely discernible difference from the 0.855 obtained for the complete 4 1/2 stage turbine in a previous investigation. The turbine was designed and the procedure embodied the following design features: (1) controlled vortex flow, (2) tailored radial work distribution, and (3) control of the location of the boundary-layer transition point on the airfoil suction surface. The efficiency forecast for the 4 1/2 stage turbine was 0.886, and the value predicted using a reference method was 0.862. The stage group performance results were used to determine the individual stage efficiencies for the condition at which design 4 1/2 stage work output was obtained. The efficiencies of stages one and four were about 0.020 lower than the predicted value, that of stage two was 0.014 lower, and that of stage three was about equal to the predicted value. Thus all the stages operated reasonably close to their expected performance levels, and the overall (4 1/2 stage) performance was not degraded by any particularly inefficient component. E.R.

N80-25339*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STATIC AND TRANSIENT PERFORMANCE OF YF-102 ENGINE WITH UP TO 14 PERCENT CORE AIRBLEED FOR THE QUIET SHORT-HAUL RESEARCH AIRCRAFT

Jack G. McArdle, Leonard Homyak, and Allan S. Moore Jun. 1980 26 p refs
(NASA-TP-1692) Avail: NTIS HC A02/MF A01 CSCL 21E

An outdoor static test stand was used to measure the steady-state and transient performance of the YF-102 turbofan engine with core airbleed. The test configuration included a bellmouth inlet and a confluent-flow exhaust system similar in size to the quiet short-haul research aircraft (QSRA) exhaust system. For the steady-state tests, the engine operated satisfactorily with core bleed up to 14 percent of the core inlet flow. For the transient tests the engine accelerated and decelerated satisfactorily with no core bleed and with core bleed up to 11 percent of the core inlet flow (maximum tested). For some of the tests the core-bleed flow rate was scheduled to vary with fan discharge pressure, to simulate the QSRA bleed requirements. No stability, surge, stall, overtemperature, combustor flameout, or other operating problems were encountered in any of the tests. Steady-state and transient engine performance data are presented in graphs, and fuel-control trajectories for typical transient tests are shown. A.R.H.

N80-26299*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DURABILITY TESTS OF SOLENOID VALVES FOR DIGITAL ACTUATORS

A. N. Baez Jun. 1980 11 p refs
(NASA-TM-81522; E-466) HC A02/MF A01 CSCL 21E

The durability of various materials used to make solenoid valve poppets and seats was investigated. Six different poppet materials and two seat materials were considered. Each material was tested for over 100 million cycles. Serious damage was found in four kinds of poppet materials tested. Less damage was evident in an aluminum poppet and in graphite composite poppet. The graphite composite poppet in combination with a Vespel seat was considered the most promising combination for use in digital electronic controls for gas turbine engines. E.D.K.

N80-27362*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPOSITE WALL CONCEPT FOR HIGH TEMPERATURE TURBINE SHROUDS: HEAT TRANSFER ANALYSIS

Francis S. Stepka and Lawrence P. Ludwig 1980 17 p refs Presented at Aerospace Congr., Los Angeles, 13-16 Oct. 1980; sponsored by Soc. of Automotive Engr.
(NASA-TM-81539; E-402) Avail: NTIS HC A02/MF A01 CSCL 21E

A heat transfer analysis was made of a composite wall shroud consisting of a ceramic thermal barrier layer bonded to a porous metal layer which, in turn, is bonded to a metal base. The porous metal layer serves to mitigate the strain differences between the ceramic and the metal base. Various combinations of ceramic and porous metal layer thicknesses and of porous metal densities and thermal conductivities were investigated to determine the layer thicknesses required to maintain a limiting temperature in the porous metal layer. Analysis showed that the composite wall offered significant air cooling flow reductions compared to an all impingement air cooled, all metal shroud. Author

N80-27363*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NUMERICAL CALCULATION OF TRANSONIC AXIAL TURBOMACHINERY FLOWS

Djordje S. Dulikravich 1980 10 p refs Presented at 7th Intern. Conf on Numerical Methods in Fluid Dyn., Stanford, Calif., 23-27 Jun. 1980; sponsored by NASA, AFOSR, NSF, and ONR
(NASA-TM-81544; E-500) Avail: NTIS HC A02/MF A01 CSCL 21E

A numerical method and the results of a computer program are presented for solving an exact, three dimensional, full potential equation that models rotating and nonrotating inviscid, absolutely irrotational, homentropic flows. Besides calculating the flows through an arbitrarily shaped rotor or stator blade row mounted on an axisymmetric hub and confined in an axisymmetric duct, the computer program is also capable of analyzing flow fields about arbitrarily shaped wing body combinations, propellers, helicopter rotors in hover, and wind turbine rotors. The governing equation is solved numerically in a fully conservative form by using an artificial time concept, a finite volume technique, rotated type dependent differencing, successive line overrelaxation, and sequential boundary conforming grid refinement. An artificial viscosity is added in fully conservative form, and an initial guess for the potential field is applied, as determined by a two dimensional cascade analysis. Author

N80-27365*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOSS MODEL FOR OFF-DESIGN PERFORMANCE ANALYSIS OF RADIAL TURBINES WITH PIVOTING-VANE, VARIABLE-AREA STATORS

Peter L. Meitner and Arthur J. Glassman 1980 22 p refs Proposed for presentation at the Aerospace Congr., Los Angeles, 13-16 Oct. 1970; sponsored by the Society of Automotive Engineers Prepared in cooperation with Army Aviation Research and Development Command, Cleveland
(NASA-TM-81532; AVRADCOM-TR-80-C-15; E-455) Avail: NTIS HC A01/MF A01 CSCL 21E

An off-design performance loss model is developed for variable-area (pivoted vane) radial turbines. The variation in stator loss with stator area is determined by a viscous loss model while the variation in rotor loss due to stator area variation (for no stator end-clearance gap) is determined through analytical matching of experimental data. An incidence loss model is also based on matching of the experimental data. A stator vane end-clearance leakage model is developed and sample calculations are made to show the predicted effects of stator vane end-clearance leakage on performance. Author

N80-28352*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OFF-DESIGN CORRELATION FOR LOSSES DUE TO PART-SPAN DAMPERS ON TRANSONIC ROTORS

William B. Roberts, James E. Crouse, and Donald M. Sandercock Jul. 1980 24 p refs
(NASA-TP-1693; E-309) Avail: NTIS HC A02/MF A01 CSCL 21E

Experimental data from 10 transonic fan rotors were used to correlate losses created by part-span dampers located near the midchord position on the rotor blades. The design tip speed of these rotors varied from 419 to 425 m/sec, and the design pressure ratio varied from 1.6 to 2.0. Additional loss caused by the dampers for operating conditions between 50 and 100 percent of design speed were correlated with relevant aerodynamic and geometric parameters. The resulting correlation predicts the variation of total-pressure-loss coefficient in the damper region to a good approximation. Author

N80-29300*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AIRCRAFT RESEARCH AND TECHNOLOGY FOR FUTURE FUELS

Jul. 1980 229 p refs Symp. held in Cleveland, Ohio, 16-17 Apr. 1980
(NASA-CP-2146; E-398) Avail: NTIS HC A11/MF A01 CSCL

21E

The potential characteristics of future aviation turbine fuels and the property effects of these fuels on propulsion system components are examined. The topics that are discussed include jet fuel supply and demand trends, the effects of refining variables on fuel properties, shale oil processing, the characteristics of broadened property fuels, the effects of fuel property variations on combustor and fuel system performance, and combuster and fuel system technology for broadened property fuels. For individual titles, see N80-29301 through N80-29330

N80-29301*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FUTURE AVIATION FUELS OVERVIEW

Gregory M. Reck *In its* Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 1-4 refs (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSCL 21D

The outlook for aviation fuels through the turn of the century is briefly discussed and the general objectives of the NASA Lewis Alternative Aviation Fuels Research Project are outlined. The NASA program involves the evaluation of potential characteristics of future jet aircraft fuels, the determination of the effects of those fuels on engine and fuel system components, and the development of a component technology to use those fuels. M.G.

N80-29309*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FUELS CHARACTERIZATION STUDIES

Gary T. Seng, Albert C. Antoine, and Francisco J. Flores *In its* Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 59-65 refs (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSCL 21D

Current analytical techniques used in the characterization of broadened properties fuels are briefly described. Included are liquid chromatography, gas chromatography, and nuclear magnetic resonance spectroscopy. High performance liquid chromatographic ground-type methods development is being approached from several directions, including aromatic fraction standards development and the elimination of standards through removal or partial removal of the alkene and aromatic fractions or through the use of whole fuel refractive index values. More sensitive methods for alkene determinations using an ultraviolet-visible detector are also being pursued. Some of the more successful gas chromatographic physical property determinations for petroleum derived fuels are the distillation curve (simulated distillation), heat of combustion, hydrogen content, API gravity, viscosity, flash point, and (to a lesser extent) freezing point. M.G.

N80-29310*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMBUSTION TECHNOLOGY OVERVIEW

Richard W. Niedzwiecki *In its* Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 67-73 refs (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSCL 21B

An overview of combustor technology developments required for use of broadened property fuels in jet aircraft is presented. The intent of current investigations is to determine the extent to which fuel properties can be varied, to obtain a data base of combustion - fuel quality effects, and to determine the trade-offs associated with broadened property fuels. Subcomponents of in-service combustors such as fuel injectors and liners, as well as air distributions and stoichiometry, are being altered to determine the extent to which fuel flexibility can be extended. Finally, very advanced technology consisting of new combustor concepts is being evolved to optimize the fuel flexibility of gas turbine combustors. M.G.

N80-29313*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASA BROADENED-SPECIFICATION FUELS COMBUSTION TECHNOLOGY PROGRAM

James S. Fear *In its* Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 95-98 (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSCL 21B

The broadened-Specification Fuels Combustion Technology program's purpose is to evolve and demonstrate the technology required to enable current and next generation high-thrust, high-bypass-ratio turbofan engines to use fuels with broadened properties and to verify the evolved technology in full scale engine tests. The three phases of the program are combustor concept screening, combustor optimization testing, and engine verification testing. Constraints for designing combustion systems are outlined and problems to be expected in the use of broadened properties fuels are listed. E.D.K.

N80-29317*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FUELS RESEARCH: COMBUSTION EFFECTS OVERVIEW

John B. Haggard, Jr. *In its* Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 115-116 (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSCL 21B

The effects of broadened property fuels on gas turbine combustors were assessed. Those physical and chemical properties of fuels that affect aviation gas turbine combustion were isolated and identified. Combustion sensitivity to variations in particular fuel properties were determined. Advanced combustion concepts and subcomponents that could lessen the effect of using broadened property fuels were also identified. R.C.T.

N80-29319*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANTIMISTING KEROSENE

Harold W. Schmidt *In its* Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 125-130 (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSCL 21D

The antimisting additive ((FM-9) was tested in terms of its propulsion systems performance. The effect of the additive on engine operation was evaluated, operating problems were identified, the adaptability of engines to antimisting kerosene was assessed, and the potential viability of this fuel for use in present and future fan jet engines was determined. R.C.T.

N80-29323*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY STUDIES OF COMBUSTOR SENSITIVITY TO ALTERNATIVE FUELS

Francis M. Humenik *In its* Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 153-160 refs (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSCL 21B

Combustion problems associated with using alternative fuels in ground power and aeropropulsion applications were studied. Rectangular sections designed to simulate large annular combustor test conditions were examined. The effects of using alternative fuels with reduced hydrogen content, increased aromatic content, and a broad variation in fuel property characteristics were also studied. Data of special interest were collected which include: flame radiation characteristics in the various combustor zones; the correponding increase in liner temperature from increased radiant heat flux; the effect of fuel bound nitrogen on oxides of nitrogen (NO sub x) emissions; and the overall total effect of fuel variations on exhaust emissions. R.C.T.

N80-29324*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FUELS RESEARCH: FUEL THERMAL STABILITY OVERVIEW

Stephen M. Cohen *In its* Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 161-168 ref (For primary document see

N80 29300 20 07)
Avail NTIS HC A11/MF A01 CSCL 21B

Alternative fuels or crude supplies are examined with respect to satisfying aviation fuel needs for the next 50 years. The thermal stability of potential future fuels is discussed and the effects of these characteristics on aircraft fuel systems are examined. Advanced fuel system technology and design guidelines for future fuels with lower thermal stability are reported. R.C.T.

N80-29328*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

FUEL SYSTEM TECHNOLOGY OVERVIEW

Robert Friedman *In its* Aircraft Res and Technol for Future Fuels Jul 1980 p 195-203 refs (For primary document see N80-29300 20-07)
Avail NTIS HC A11/MF A01 CSCL 21E

Fuel system research and technology studies are being conducted to investigate the correlations and interactions of aircraft fuel system design and environment with applicable characteristics of the fuel. Topics include: (1) analysis of in-flight fuel temperatures, (2) fuel systems for high freezing point fuels; (3) experimental study of low temperature pumpability; (4) full scale fuel tank simulation; and (5) rapid freezing point measurement. E.D.K.

N80-29332*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INVESTIGATION OF PERFORMANCE DETERIORATION OF THE CF6/JT9D, HIGH-BYPASS RATIO TURBOFAN ENGINES

Joseph A. Ziemianski and Charles M. Mehalic 1980 22 p refs Proposed for presentation at the 56th AGARD Propulsion and Energetics Symp on Turbine Engine Testing, Turin, 29 Sep. - 3 Oct. 1980 and SAE Aerospace Congr., Los Angeles, 13-16 Oct. 1980
(NASA-TM-81552; E-511) Avail: NTIS HC A02/MF A01 CSCL 21E

The aircraft energy efficiency program within NASA is developing technology required to improve the fuel efficiency of commercial subsonic transport aircraft. One segment of this program includes engine diagnostics which is directed toward determining the sources and causes of performance deterioration in the Pratt and Whitney Aircraft JT9D and General Electric CF6 high-bypass ratio turbofan engines and developing technology for minimizing the performance losses. Results of engine performance deterioration investigations based on historical data, special engine tests, and specific tests to define the influence of flight loads and component clearances on performance are presented. The results of analysis of several damage mechanisms that contribute to performance deterioration such as blade tip rubs, airfoil surface roughness and erosion, and thermal distortion are also included. The significance of these damage mechanisms on component and overall engine performance is discussed. A.R.H.

N80-29333*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESCRIPTION OF THE WARM CORE TURBINE FACILITY RECENTLY INSTALLED AT NASA LEWIS RESEARCH CENTER

W. J. Whitney, R. G. Stabe, and T. P. Moffitt 1980 18 p refs Proposed for presentation at Aerospace Congr., Los Angeles, 13-16 Oct. 1980; sponsored by Am. Soc. of Automotive Engrs.
(NASA-TM-81562; E-524) Avail: NTIS HC A02/MF A01 CSCL 21E

The two net facilities were installed and operated at their design, or rated conditions. The important feature of both of these facilities is that the ratio of turbine inlet temperature to coolant temperature encountered in high temperature engines can be duplicated at moderate turbine inlet temperature. The limits of the facilities with regard to maximum temperature, maximum pressure, maximum mass flow rate, turbine size, and dynamometer torque-speed characteristics are discussed. Author

N80-29358*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

STATE-OF-THE-ART SIAION MATERIALS

Sunil Dutta *In* AGARD Ceram. for Turbine Eng. Appl. Mar. 1980 15 p refs (For primary document see N80-29342 20-07)
Avail NTIS HC A16/MF A01 CSCL 21E

The state of the art of SiAlONs is examined. The review includes work on phase relations, crystal structure, synthesis, fabrication, and properties of various SiAlONs. The essential features of compositions, fabrication methods, and microstructure are reviewed. High temperature flexure strength, creep, fracture toughness, oxidation, and thermal shock resistance are discussed. These data are compared to those for some currently produced silicon nitride ceramics to assess the potential of SiAlON materials for use in advanced gas turbine engines. E.D.K.

N80-31399*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

REVERSE THRUST PERFORMANCE OF THE QCSEE VARIABLE PITCH TURBOFAN ENGINE

N. E. Samanich, D. C. Reemsnyder, and H. E. Blodmer 1980 57 p refs Presented at the Aerospace Congr., Los Angeles, 13-16 Oct. 1980; sponsored by Am. Soc. of Automotive Engr.
(NASA-TM-81558; E-519) Avail: NTIS HC A04/MF A01 CSCL 21E

Results of steady state reverse and forward to reverse thrust transient performance tests are presented. The original quiet, clean, short haul, experimental engine four segment variable fan nozzle was retested in reverse and compared with a continuous, 30 deg half angle conical exlet. Data indicated that the significantly more stable, higher pressure recovery flow with the fixed 30 deg exlet resulted in lower engine vibrations, lower fan blade stress, and approximately a 20 percent improvement in reverse thrust. Objective reverse thrust of 35 percent of takeoff thrust was reached. Thrust response of less than 1.5 sec was achieved for the approach and the takeoff to reverse thrust transients. Author

N80-31400*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN EXPERIMENTAL EVALUATION OF THE PERFORMANCE DEFICIT OF AN AIRCRAFT ENGINE STARTER TURBINE

Jeffrey E. Hass, Richard J. Roelke, and Paul Hermann (Sunstrand Corp., Rockford, Ill.) 1980 21 p ref Presented at the Aerospace Congr., Los Angeles, 13-16 Oct. 1980; sponsored by Am. Soc. of Automotive Engr.
(NASA-TM-81571; E-539) Avail: NTIS HC A02/MF A01 CSCL 21E

An experimental investigation was made to determine the reasons for the low aerodynamic performance of a 13.5 centimeter tip diameter aircraft engine starter turbine. The investigation consisted of an evaluation of both the stator and the stage. An approximate ten percent improvement in turbine efficiency was obtained when the honeycomb shroud over the rotor blade tips was filled to obtain a solid shroud surface. Author

N80-31401*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE NASA HIGH-SPEED TURBOPROP PROGRAM

James F. Dugan, Brent A. Miller, Edwin J. Graber, and David A. Sagerser 1980 48 p refs Presented at the Aerospace Congr., Los Angeles, 13-16 Oct. 1980; sponsored by the Am. Soc. of Automotive Engr.
(NASA-TM-81561; E-452) Avail: NTIS HC A03/MF A01 CSCL 01C

Technology readiness for Mach 0.7 to 0.8 turboprop powered aircraft with the potential for fuel savings and DOC reductions of up to 30 and 15 percent respectively relative to current in-service aircraft is addressed. The areas of propeller aeroacoustics, propeller structures, turboprop installed performance, aircraft cabin environment, and turboprop engine and aircraft studies are emphasized. Large scale propeller characteristics and high speed propeller flight research tests using a modified testbed aircraft are also considered. J.M.S.

N80-31402*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IMPROVED COMPONENTS FOR ENGINE FUEL SAVINGS

Robert J. Antl and John E. McAulay 1980 33 p refs Presented at the Aerospace Congr., Los Angeles, 13-16 Oct. 1980; sponsored by Am. Soc. of Automotive Engr.

(NASA-TM-81577; E-506) Avail: NTIS HC A03/MF A01 CSCL 21E

The Engine Component Improvement (ECI) Project formulated to address near term improvements for current engines is described with emphasis on the development of component technologies to reduce the fuel consumption of CF6, JT9D, and JT8D engines. The technical and economical acceptability and the fuel saving systems to relate the variation of cost on blade size. Geometries typical of blade designs at 24, 30, 36 and 42 blades per disc were used. The impact of individual process yield factors on costs was also assessed as well as effects of process parameters, raw materials, labor rates and consumable items. A.R.H.

N80-32394*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE DETERIORATION OF COMMERCIAL HIGH-BYPASS RATIO TURBOFAN ENGINES

Charles M. Mehalic and Joseph A. Ziemianski 1980 30 p refs Presented at SAE Aerospace Congr., Los Angeles, 13-16 Oct. 1980 and at the 56th AGARD Propulsion and Energetics Symp. on Turbine Engine Testing, Turin, 29 Sep. - 3 Oct. 1980 Revised

(NASA-TM-81552-Rev; E-511-Rev) Avail: NTIS HC A03/MF A01 CSCL 21E

The results of engine performance deterioration investigations based on historical data, special engine tests, and specific tests to define the influence of flight loads and component clearances on performance are presented. The results of analyses of several damage mechanisms that contribute to performance deteroration such as blade tip rubs, airfoil surface roughness and erosion, and thermal distortion are also included. The significance of these damage mechanisms on component and overall engine performance is discussed. E.D.K.

N80-32395*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE ENERGY EFFICIENT ENGINE PROJECT Status Report

Lawrence E. Macioce, John W. Schaefer, and Neal T. Saunders 1980 42 p refs Presented at the Aerospace Congr., Los Angeles, 13-16 Oct. 1980

(NASA-TM-81566; E-531) Avail: NTIS HC A03/MF A01 CSCL 21E

The Energy Efficient Engine Project is directed at providing, by 1984, the advanced technologies which could be used for a generation of fuel conservative turbofan engines. The project is conducted through contracts with the General Electric Company and Pratt and Whitney Aircraft. The scope of the entire project and the current status of these efforts are summarized. A description of the preliminary designs of the fully developed engines is included and the potential benefits of these advanced engines, as well as highlights of some of the component technology efforts conducted to date, are discussed. E.D.K.

N80-32396*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOW-PRESSURE PERFORMANCE OF ANNULAR, HIGH-PRESSURE (40 ATM) HIGH-TEMPERATURE (2480 K) COMBUSTION SYSTEM

Jerrold D. Wear Washington Sep. 1980 20 p refs

(NASA-TP-1713; E-372) Avail: NTIS HC A02/MF A01 CSCL 21E

Experimental tests were conducted to develop a combustion system for a 40 atmosphere pressure, 2480 K exhaust gas temperature, turbine cooling facility. The tests were conducted in an existing facility with a maximum pressure capability of 10 atmospheres and where inlet air temperatures as high as 894 K could be attained. Exhaust gas temperatures were as high as 2365 K. Combustion efficiences were about 100 percent over a fuel air ratio range of 0.016 to 0.056. Combustion efficiency decreased at leaner and richer ratios when the inlet air temperature was 589 K. Data are presented that show the effect of fuel air ratio and inlet air temperature on liner metal temperature. Isothermal system pressure loss as a function of diffuser inlet Mach number is also presented. Data included exhaust gas pattern factors, unburned hydrocarbon, carbon monoxide, and oxides of nitrogen emission index values, and smoke numbers. Author

N80-33410*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EXPERIMENTAL PERFORMANCE AND ANALYSIS OF 15.04-CENTIMETER-TIP-DIAMETER, RADIAL-INFLOW TURBINE WITH WORK FACTOR OF 1.126 AND THICK BLADING

Kerry L. McLallin and Jeffrey E. Haas Oct. 1980 21 p refs Prepared in cooperation with Army Aviation Research and Development Command, St. Louis, Mo.

(NASA-TP-1730; E-391; AVRADCOM-TR-80-09) Avail: NTIS HC A02/MF A01 CSCL 21E

The aerodynamic design, the performance, and an internal loss breakdown were examined for a 15.04 cm tip diameter, radial-inflow turbine. The design application was to drive a two stage, 10 to 1 pressure ratio compressor with a mass flow of 0.952 kg/sec and a rotative speed of 70,000 rmp. The turbine inlet temperature was 1478 K, and the turbine was designed with blades thick enough for internal cooling passages. The rotor tip diameter was limited to 86 percent of optimum in order to obtain a reduced tip speed design. The turbine was fabricated with solid, uncooled blading and tested in air at nominal inlet pressure and temperature of 1.379 x 10000 N/sq m and 322.2 K, respectively. Results indicated the turbine total efficiency to be 5.3 points less than design. Analysis of these results has indicated the deficit in performance to be due to stator secondary flow losses, vaneless space surface friction losses, and trailing edge wake mixing losses. R.C.T.

A80-10033 * # **Identification and dual adaptive control of a turbojet engine.** W. Merrill (NASA, Lewis Research Center, Cleveland, Ohio) and G. Leininger (Toledo, University, Toledo, Ohio). *International Federation of Automatic Control, Symposium on Identification and System Parameter Estimation, 5th, Darmstadt, West Germany, Sept. 24-28, 1979, Paper.* 8 p. 14 refs. Grant No. NGR-36-010-024.

The objective of this paper is to utilize the design methods of modern control theory to realize a 'dual-adaptive' feedback control unit for a highly non-linear single spool airbreathing turbojet engine. Using a very detailed and accurate simulation of the non-linear engine as the data source, linear operating point models of unspecified dimension are identified. Feedback control laws are designed at each operating point for a prespecified set of sampling rates using sampled-data output regulator theory. The control system sampling rate is determined by an adaptive sampling algorithm in correspondence with turbojet engine performance. The result is a 'dual-adpative' control law that is functionally dependent upon the sampling rate selected and environmental operating conditions. Simulation transients demonstrate the utility of the dual-adaptive design to improve on-board computer utilization while maintaining acceptable levels of engine performance. (Author)

A80-10034 * # **Turbine engine altitude chamber and flight testing with liquid hydrogen.** E. W. Conrad (NASA, Lewis Research Center, Cleveland, Ohio). *Deutsche Gesellschaft für Luft- und Raumfahrt and Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, International Symposium on Hydrogen in Air Transportation, Stuttgart, West Germany, Sept. 11-14, 1979, Paper.* 20 p, 12 refs.

In the late fifties the Lewis Research Center evaluated experimentally the use of hydrogen using three different turbojet engines in altitude test chambers. One of these engines was later flown experimentally using liquid hydrogen fuel. This paper is a brief overview of the significant aspects of this exploratory research and gives a few implications of the results to modern turbine engines. A subsequent contract dealing with a positive displacement pump operating on liquid hydrogen is discussed and some aspects of liquid hydrogen propellant systems, reflected by rocket booster experience are treated briefly. Areas requiring further research and technology effort are delineated. (Author)

A80-17737 * # **Preparing aircraft propulsion for a new era in energy and the environment.** W. L. Stewart, D. L. Nored, J. S. Grobman, C. E. Feiler, and D. A. Petrash (NASA, Lewis Research Center, Cleveland, Ohio). *Astronautics and Aeronautics*, vol. 18, Jan. 1980, p. 18-31, 37. 22 refs.

Improving fuel efficiency, new sources of jet fuel, and noise and emission control are subjects of NASA's aeronautics program. Projects aimed at attaining a 5% fuel savings for existing engines and a 13-22% savings for the next generation of turbofan engines using advanced components, and establishing a basis for turboprop-powered commercial air transports with 30-40% savings over conventional turbofan aircraft at comparable speeds and altitudes, are discussed. Fuel sources are considered in terms of reduced hydrogen and higher aromatic contents and resultant higher liner temperatures, and attention is given to lean burning, improved fuel atomization, higher freezing-point fuel, and deriving jet fuel from shale oil or coal. Noise sources including the fan, turbine, combustion process, and flow over internal struts, and attenuation using acoustic treatment, are discussed, while near-term reduction of polluting gaseous emissions at both low and high power, and far-term defining of the minimum gaseous-pollutant levels possible from turbine engines are also under study. J.P.B.

A80-18253 * # **Computer simulation of engine systems.** L. H. Fishbach (NASA, Lewis Research Center, Flight Performance Section, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0051.* 15 p. 32 refs.

The paper discusses the availability throughout the government and industry of analytical methods for calculating both the steady state and transient performance of an aircraft engine during an entire flight regime. The historical development of some of the analytical tools capable of evaluating installation effects on engine performance is traced and their present status is described. C.F.W.

A80-19300 * # **Engine component improvement program - Performance improvement.** J. E. McAulay (NASA, Lewis Research Center, Performance Improvement Section, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0223.* 10 p. 7 refs.

The Engine Component Improvement (ECI) Program is NASA sponsored and is specifically directed at reducing the fuel consumption of commercial aircraft in the near-term. As part of the ECI program, a Performance Improvement (PI) effort aimed at developing fuel saving and retention components for new production and retrofit of JT9D, JT8D, and CF6 engines is underway. This paper reviews the manner in which the PI concepts were selected for development and summarizes the current status of each of the 16 NASA selected concepts. (Author)

A80-20968 * # **Scale model performance test investigation of exhaust system mixers for an Energy Efficient Engine /E3/ propulsion system.** A. P. Kuchar (General Electric Co., Cincinnati, Ohio) and R. Chamberlin (NASA, Lewis Research Center, Energy Conservative Engine Office, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0229.* 10 p.

A scale model performance test was conducted as part of the NASA Energy Efficient Engine (E3) Program, to investigate the geometric variables that influence the aerodynamic design of exhaust system mixers for high-bypass, mixed-flow engines. Mixer configuration variables included lobe number, penetration and perimeter, as well as several cutback mixer geometries. Mixing effectiveness and mixer pressure loss were determined using measured thrust and nozzle exit total pressure and temperature surveys. Results provide a data base to aid the analysis and design development of the E3 mixed-flow exhaust system. (Author)

A80-32887 * # **Aeropropulsion in year 2000.** R. J. Weber (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, International Meeting and Technical Display on Global Technology 2000, Baltimore, Md., May 6-8, 1980, Paper 80-0914.* 11 p. 5 refs.

The paper demonstrates that many advances can be anticipated in propulsion systems for aircraft in the next 20 years. A survey is presented of probable future engine types, including convertible engines for helicopters, turboprops for fuel efficient airliners, and variable cycle engines for supersonic transports. Also examined is the use of rotary engines in general aviation aircraft. Finally, a review is given of related technology improvements in propellers, materials, noise suppression, and digital electronic controls. M.E.P.

A80-35101 * # **Engine environmental effects on composite behavior.** C. C. Chamis and G. T. Smith (NASA, Lewis Research Center, Cleveland, Ohio). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Part 2. (A80-34993 14-39) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 987-997. 7 refs. (AIAA 80-0695)

The effects of turbojet engine environmental saturation moisture and temperatures up to 300 F on composites were investigated. It was found that epoxy resin composites absorbed the most moisture (2 wt %), while polyimide resin composites absorbed 0.8%. High moisture and 250 F degraded the flexular and interlaminar shear properties, and the environmental and impact conditions severely damaged epoxy composites. The impact damage of fiber composites in moisture-temperature environments can be assessed with finite element and composite mechanics analyses. Engine operation environmental conditions of 0.8% moisture and 140 F had no discernible effect on the fatigue resistance of composite fan exit guide vanes, which can be designed to exceed engine operational requirements using composite materials. A.T.

A80-37482 * # **Airbreathing propulsion component technologies.** C. Rosen (NASA, Washington, D.C.), B. Koff (General Electric Co., Aircraft Engine Group, Cincinnati, Ohio), and M. Hartmann (NASA, Lewis Research Center, Fluid Systems Components Div., Cleveland, Ohio). *Astronautics and Aeronautics*, vol. 18, June 1980, p. 42-53. 22 refs.

The article suggests that the 1980's will see significant improvements in virtually all gas-turbine engine components and their materials and structural design methods. These improvements will be made possible by improved theoretical models, laser Doppler measurement techniques, advances in rotor-spool technology, the evolution of engine controls, etc. It is suggested that the engine components field should expect broad and steady advances in the technologies of flow, materials, and structures in terms of scope, precision, and tools of design. B.J.

A80-39635 * # **Significance of thermal contact resistance in two-layer, thermal-barrier-coated turbine vanes.** C. H. Liebert and E. Gaugler (NASA, Lewis Research Center, Cleveland, Ohio). *American Vacuum Society, International Conference on Metallurgical Coatings, San Diego, Calif., Apr. 21-25, 1980, Paper.* 9 p. 11 refs.

The paper studies calculated and measured metal wall temperatures of uncoated vanes and the same vanes coated with a thermal barrier coating system of NiCrAlY bond and yttria-stabilized zirconia ceramic. It is shown that thermal contact between layers is negligible. The significance of data scatter and of published ceramic thermal conductivity values is discussed. V.T.

A80-39638 * # **Far-field radiation of AFT turbofan noise.** E. J. Rice and A. V. Saule (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 99th, Atlanta, Ga., Apr. 21-25, 1980, Paper.* 23 p. 23 refs.

The far-field radiation from the end of an exhaust duct is studied using both approximate and exact methods. Experimental data of narrow-band tone noise from static tests are compared to a multimodal radiation pattern. It is pointed out that possibly the exhaust noise in the far-field is inherently more difficult to attenuate than an inlet noise using duct suppressors. V.T.

A80-38640 * # **Comparison of several inflow control devices for flight simulation of fan tone noise using a JT15D-1 engine.** J. G. McArdle, W. L. Jones, L. J. Heidelberg, and L. Homyak (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 6th, Hartford, Conn., June 4-6, 1980, Paper 80-1025.* 45 p. 12 refs.

The paper describes the tests of four devices intended to reduce inflow disturbances and turbulences using a JT15D-1 turbofan engine. The tests were made to simulate the in-flight fan tone noise; the inflow control devices (ICD's) consisted of honeycomb/screen structures mounted over the engine inlet. The ICD's ranged from 1.6 to 4 fan diameters in size, and were made with several fabrication methods. All the ICD's significantly reduced the BPF tone in the far-field directivity patterns, but the smallest ICD's introduced propagating modes which could be recognized by additional lobes in the patterns. The JT15D-1 engine had a tone source which generated a strong propagating mode at fan speeds corresponding to 'approach' power and higher. Data from a typical transducer showed that the unsteady inflow distortion modes were eliminated or reduced when either of the ICD's was installed. A.T.

A80-38651 * # **QCSEE UTW engine powered-lift acoustic performance.** I. J. Loeffler, N. E. Samanich, and H. E. Bloomer (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 6th, Hartford, Conn., June 4-6, 1980, Paper 80-1065.* 34 p. 17 refs.

Powered-lift acoustic tests of a quiet clean short-haul experimental engine (QCSEE) under-the-wing (UTW) engine are described. Engine and wing configurations are outlined, along with instrumentation and test facilities. The results of these tests are reported. In addition, the UTW engine powered-lift performance is compared with that of the previously tested QCSEE over-the-wing (OTW) engine. V.T.

A80-38902 * # **Advanced component technologies for energy-efficient turbofan engines.** N. T. Saunders (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1086.* 11 p. 6 refs.

The paper reviews NASA's Energy Efficient Engine Project which was initiated to provide the advanced technology base for a new generation of fuel-conservative engines for introduction into airline service by the late 1980s. Efforts in this project are directed at advancing engine component and systems technologies to a point of demonstrating technology-readiness by 1984. Early results indicate high promise in achieving most of the goals established in the project. V.P.

A80-38903 * # **Experimental evaluation of exhaust mixers for an Energy Efficient Engine.** H. Kozlowski (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.) and G. Kraft (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1088.* 7 p.

Static scale model tests were conducted to evaluate exhaust system mixers for a high bypass ratio engine as part of the NASA sponsored Energy Efficient program. Gross thrust coefficients were measured for a series of mixer configurations which included variations in the number of mixer lobes, tailpipe length, mixer penetration, and length. All of these parameters have a significant impact on exhaust system performance. In addition, flow visualization pictures and pressure/temperature traverses were obtained for selected configurations. Parametric performance trends are discussed and the results considered relative to the Energy Efficient Engine program goals. (Author)

A80-41514 * # **CF6-50 Short Core Exhaust Nozzle.** D. J. Dusa (General Electric Co., Cincinnati, Ohio) and F. J. Hrach (NASA, Lewis Research Center, Engine Component Improvement Office, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1196.* 6 p.

The General Electric CF6-50 engine nacelle was originally equipped with both fan nozzle and core nozzle thrust reversers. Many airline operators later deactivated the core reverser. Elimination of the core reverser enabled design changes to be made to help improve performance. A reduction in core nozzle length of approximately two feet was possible. This concept, defined as the Short Core Exhaust Nozzle, was evaluated in engine ground tests, including performance, acoustic, and endurance tests under the NASA/Lewis Engine Component Improvement Program. The test results verified the performance predictions from scale model tests. The Short Core Exhaust Nozzle provides an internal cruise SFC reduction of 0.9% without an increase in engine noise. The nozzle hardware successfully completed 1000 flight cycles of endurance testing with no signs of distress. (Author)

A80-41515 * # **Influence of pressure driven secondary flows on the behavior of turbofan forced mixers.** B. Anderson, L. Povinelli, and W. Gerstenmaier (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1198.* 27 p. 12 refs.

An analytical and experimental study was performed to determine the influence of pressure driven secondary flows on the behavior of turbofan forced mixer nozzles. The basic secondary flow structure entering the nozzle was identified experimentally and was composed of a strong vortex system aligned with the radial interface between the fan and core streams. A generic secondary flow vortex structure was constructed for input to the analysis to represent the large scale structure of this inflow condition. Comparison between experiment and analysis at five axial stations showed very good agreement and indicated that this vortex system was convected downstream and dominated the mixing process. (Author)

A80-42147 * # **Experimental study of low aspect ratio compressor blading.** L. Reid and R. D. Moore (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-6.* 8 p. Members, $1.50; nonmembers, $3.00.

The paper presents a study of low aspect blading for the inlet stages of a high pressure ratio, high-speed core compressor. The basic overall design variables were stage pressure ratio and blade aspect ratio; these four stages represent two levels of total pressure ratio, two levels of rotor blade aspect ratio, and two levels of stator vane aspect ratios. Comparisons of the overall performance, radial distributions of performance parameters, diffusion factors at the near-stall conditions, blade element data, and the axial distribution of rotor tip static pressures yielded the following results: (1) higher peak pressure ratio, high stage and rotor efficiencies, and greater stall margin were obtained with the lower aspect ratio blading, (2) the lower aspect ratio blading showed improved performance over the entire blade span, and (3) the lower aspect ratio rotors operated at higher diffusion factors and higher incidence angles over the entire blade span. A.T.

A80-42154 * # **Performance of annular prediffuser-combustor systems.** W. B. Wagner, S. Tanrikut (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.), and D. E. Sokolowski (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-15.* 12 p. 19 refs. Members, $1.50; nonmembers, $3.00.

Results of an experimental investigation of the aerodynamic performance of several annular prediffuser-combustor systems are presented. Three curved wall, dump prediffusers of different length, area ratio, and turning angle were tested with and without a simulated combustor located downstream of the prediffuser. Performance was significantly influenced by the presence of the combustor. Pressure recovery and flow losses were determined as a function of prediffuser inlet velocity profile, flow extraction at the prediffuser inlet, axial and radial location of the combustor front end, and distribution of the flow in the combustor. Axial location of the combustor was found to be the most significant parameter influencing system performance. (Author)

A80-42164 * # **Atomizing characteristics of swirl can combustor modules with swirl blast fuel injectors.** R. D. Ingebo (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-30.* 7 p. 8 refs. Members, $1.50; nonmembers, $3.00.

Cold flow atomization tests of several different designs of swirl can combustor modules were conducted in a 7.6 cm diameter duct at airflow rates (per unit area) of 7.3 to 25.7 g/sq cm sec and water flow rates of 6.3 to 18.9 g/sec. The effect of air and water flow rates on the mean drop size of water sprays produced with the swirl blast fuel injectors were determined. Also, from these data it was possible to determine the effect of design modifications on the atomizing performance of various fuel injector and air swirler configurations. The trend in atomizing performance, as based on the mean drop size, was then compared with the trends in the production of nitrogen oxides obtained in combustion studies with the same swirl can combustors. (Author)

A80-42199 * # **Low NO/x/ heavy fuel combustor program.** E. Lister (U.S. Department of Energy, Germantown, Md.), R. W. Niedzwiecki, and L. Nichols (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-69.* 10 p. Members, $1.50; nonmembers, $3.00.

The paper deals with the 'Low NO/x/ Heavy Fuel Combustor Program'. Main program objectives are to generate and demonstrate the technology required to develop durable gas turbine combustors for utility and industrial applications, which are capable of sustained, environmentally acceptable operation with minimally processed petroleum residual fuels. The program will focus on 'dry' reductions of oxides of nitrogen (NO/x/), improved combustor durability and satisfactory combustion of minimally processed petroleum residual fuels. Other technology advancements sought include: fuel flexibility for operation with petroleum distillates, blends of petroleum distillates and residual fuels, and synfuels (fuel oils derived from coal or shale); acceptable exhaust emissions of carbon monoxide, unburned hydrocarbons, sulfur oxides and smoke; and retrofit capability to existing engines. (Author)

A80-42258 * # **Results from tests on a high work transonic turbine for an energy efficient engine.** D. E. Crow, H. Welna, I. D. Singer (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.), and M. R. Vanco (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-146.* 9 p. Members, $1.50; nonmembers, $3.00. Contract No. NAS3-20646.

The experimental results of the evaluation of two high work, transonic, single-stage turbines investigated under the Energy Efficient Engine (E3) Program are presented. The objective of the E3 program is to provide an advanced technology base for a new generation of fuel-conservative turbofan engines. A single-stage turbine required fewer cooled airfoils, a reduced number of leakage paths and no interstage seals. These advanced energy efficient engines require high engine pressure ratios resulting in high expansion ratio, transonic, turbine designs which must have high aerodynamic efficiency. The goal of the turbine program is to develop a high pressure turbine that is compatible with the overall engine design and has an uncooled efficiency of 90.8 percent. (Author)

A80-43283 * # **A theoretical and experimental investigation of propeller performance methodologies.** K. D. Korkan, G. M. Gregorek (Ohio State University, Columbus, Ohio), and D. C. Mikkelson (NASA, Lewis Research Center, Subsonic Propulsion Section, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1240.* 22 p. 37 refs. Grant No. NsG-3247.

This paper briefly covers aspects related to propeller performance by means of a review of propeller methodologies; presentation of wind tunnel propeller performance data taken in the NASA Lewis Research Center 10 x 10 wind tunnel; discussion of the predominent limitations of existing propeller performance methodologies; and a brief review of airfoil developments appropriate for propeller applications. (Author)

A80-42284 * # **CF6 fan performance improvement.** R. F. Patt (General Electric Co., Evandale, Ohio) and D. C. Reemsnyder (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-178.* 11 p. Members, $1.50; nonmembers, $3.00.

A significant portion of the NASA-sponsored Performance Improvement Program for the CF6 engine was the development of an improved fan concept. This involved aerodynamic redesign of the CF6 fan blade to increase fan efficiency while retaining the mechanical integrity, operability, and acoustic characteristics of the existing blade. A further improvement in performance was obtained by adding a fan case stiffener ring to decouple blade-case vibrational characteristics, permitting a significant reduction in running tip clearance. Engine testing was performed to establish the performance, mechanical and acoustic properties of the new design relative to the current fan, and to establish power management characteristics for the CF6-50C2/E2 engine. A significant improvement in cruise power SFC of 1.8 percent was demonstrated in Sea Level testing projected to altitude flight conditions. (Author)

A80-44230 * # **JT9D-7A /SP/ jet engine performance deterioration trends.** G. P. Richter (NASA, Lewis Research Center, Cleveland, Ohio), W. J. Olsson (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.), and N. B. Andersen (Pan American World Airways, Inc., Kennedy International Airport, N.Y.). *Hamilton Burr Publishing Co., International Aircraft Maintenance Engineering Exhibition and Conference, Dallas, Tex., Apr. 8-10, 1980, Paper.* 21 p.

It is noted that increasing fuel costs and the decreasing availability of fuel supplies have lead to an increase in the importance of maintaining good specific fuel consumption over the life cycle of jet engines. Attention is given to an engine diagnostics program sponsored by NASA Lewis Research Center which has the objectives of identifying and quantifying the levels, trends, and causes of engine performance deterioration. It is reported that as part of the program, a series of installed engine calibrations were performed on two new Pan American World Airways 747 SP aircraft. A discussion of this specific test program and the results of the analysis of the data are presented. M.E.P.

A80-44491 * # **Prediction of unsuppressed jet engine exhaust noise in flight from static data.** J. R. Stone (NASA, Lewis Research Center, Jet Acoustics Branch, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 6th, Hartford, Conn., June 4-6, 1980, Paper 80-1008.* 24 p. 22 refs.

In order to assess the impact of aircraft noise on the environment in the vicinity of an airport, it is essential that a methodology be developed for predicting in-flight exhaust noise from static data. Such a methodology is presented in this paper and is compared with experimental data for several unsuppressed turbojet engines. For each engine, static data over a range of jet velocities are compared with the predicted jet mixing noise and shock-cell noise. The static engine noise over and above the jet and shock noises is identified as 'excess' noise. The excess noise data are then empirically correlated to smooth the spectral and directivity relations and account for variations in test conditions. This excess noise is then projected to flight based on the assumption that the only effects of flight are a Doppler frequency shift and a level change. The effects of flight on jet mixing noise and shock noise are computed by published NASA methods. (Author)

A80-48013 * # **Similarity tests of turbine vanes - Effects of ceramic thermal barrier coatings.** H. J. Gladden (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers and American Institute of Chemical Engineers, Joint National Heat Transfer Conference, Orlando, Fla., July 27-30, 1980, ASME Paper 80-HT-24.* 9 p. 12 refs. Members, $1.50; nonmembers, $3.00.

The role of material thermal conductivity was analyzed for its effect on the thermal performance of air-cooled gas turbine components coated with a ceramic thermal barrier material when tested at reduced temperatures and pressures. This study shows that the thermal performance can be evaluated reliably at reduced gas and coolant conditions. However, thermal conductivity corrections are required for the data at reduced conditions. These corrections for a ceramic thermal barrier coated vane are significantly different than the corrections for an uncoated vane. Comparison of uncorrected test data, therefore, would show erroneously that the thermal barrier coating was ineffective. When thermal conductivity corrections are applied to the test data these data are then shown to be representative of engine data and also show that the thermal barrier coating increases the vane cooling effectiveness by 12.5 precent. (Author)

A80-48014 * # **Uncertainties in predicting turbine blade metal temperatures.** F. S. Stepka (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers and American Institute of Chemical Engineers, Joint National Heat Transfer Conference, Orlando, Fla., July 27-30, 1980, ASME Paper 80-HT-25.* 8 p. 12 refs. Members, $1.50; nonmembers, $3.00.

An analysis is presented of the effects of the hot-gas and coolant temperatures, the gas-to-blade and blade-to-coolant heat transfer coefficients, and the thermal conductances of a metal wall and a ceramic thermal-barrier coating on the prediction of local turbine-blade surface temperatures. The analysis was applied to the conditions of an advanced turbofan engine and a 1700 K, 40 atm turbine test rig, and to conditions that simulated the engine at 756 K and 15.6 atm. The results showed that with current information on boundary conditions, geometry, heat-transfer coefficients, and material thermal properties, the uncertainty in predicting and verifying local turbine-blade surface temperatures in an average engine is 98 kelvins or 7.6% of the reference metal absolute temperature for uncoated blades, and 62 kelvins or 5.7% for ceramic-thermal-barrier-coated blades. A.T.

N80-10221*# Pratt and Whitney Aircraft Group, East Hartford, Conn.

EXPERIMENTAL EVALUATION OF A LOW EMISSIONS HIGH PERFORMANCE DUCT BURNER FOR VARIABLE CYCLE ENGINES (VCE) Final Report

R. P. Lohman and R. J. Mador 1979 117 p refs
(Contract NAS3-20602)
(NASA-CR-159694; PWA-5513-32) Avail: NTIS HC A05/MF A01 CSCL 21E

A three-stage Vorbix duct burner was evaluated to determine the performance and emissions characteristics of this concept and to refine the configuration to provide acceptable durability and operational characteristics for its use in the VCE Testbed Program. The tests were conducted at representative takeoff, transonic climb and supersonic cruise inlet conditions for the VSCE-502B study engine. The carbon monoxide and unburned hydrocarbon emissions were low at all three operating conditions with combustion efficiencies in excess of 99.7 percent, as compared to the goal of 99.0 percent. Nitric oxide emissions were moderate but in excess of the program goal of 1 gm/kg at takeoff. The thrust efficiency exceeded the goal level of 94.5 percent reaching a value of 97 percent at supersonic cruise. Soft ignition, the absence of combustion generated acoustic instabilities and liner temperature levels acceptable for experimental hardware were also demonstrated. The total pressure loss across the duct burner, at 6.76 the loss mechanisms have been indentified and, in one configuration 40 percent of this excess loss was eliminated without comprising the emissions or thrust efficiency. A.R.H.

N80-10222*# Pratt and Whitney Aircraft, East Hartford, Conn. Chemical Products Div.

VSCE TECHNOLOGY DEFINITION STUDY Final Report

R. A. Howlett and R. B. Hunt Aug. 1979 114 p refs
(Contract NAS3-21389)
(NASA-CR-159730; PWA-5630-11) Avail: NTIS HC A06/MF A01 CSCL 21E

Refined design definition of the variable stream control engine (VSCE) concept for advanced supersonic transports is presented. Operating and performance features of the VSCE are discussed, including the engine components, thrust specific fuel consumption, weight, noise, and emission system. A preliminary engine design is presented. A.W.H.

N80-12091*# Pratt and Whitney Aircraft Group, East Hartford, Conn.

DESIGN, DURABILITY AND LOW COST PROCESSING TECHNOLOGY FOR COMPOSITE FAN EXIT GUIDE VANES

S. S. Blecherman Aug. 1979 139 p refs
(Contract NAS3-21037)
(NASA-CR-159677; PWA-5570-37) Avail: NTIS HC A07/MF A01 CSCL 21E

A lightweight composite fan exit guide vane for high bypass ratio gas turbine engine application was investigated. Eight candidate material/design combinations were evaluated by NASTRAN finite element analyses. A total of four combinations were selected for further analytical evaluation, part fabrication by two ventors, and fatigue test in dry and wet condition. A core and shell vane design was chosen in which the unidirectional graphite core fiber was the same for all candidates. The shell material, fiber orientation, and ply configuration were varied. Material tests were performed on raw material and composite specimens to establish specification requirements. Pre-test and post-test microstructural examination and nondestructive analyses were conducted to determine the effect of material variations on fatigue durability and failure mode. Relevant data were acquired with respect to design analysis, materials properties, inspection standards, improved durability, weight benefits, and part price of the composite fan exit guide vane. R.C.T.

N80-13041*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif

FLIGHT TEST OF NAVIGATION AND GUIDANCE SENSOR ERRORS MEASURED ON STOL APPROACHES

David N. Warner and F. J. Moran Dec. 1979 42 p
(NASA-TM-81154, A-8008) Avail: NASA. Ames Res. Center.
(Contract NAS3-21238)
(NASA-CR-159693; D180-25481-3-Vol-3) Avail: NTIS HC A18/MF A01 CSCL 21E

A computerized method which utilizes the engine performance data and estimates the installed performance of aircraft gas turbine engines is presented. This installation includes: engine weight and dimensions, inlet and nozzle internal performance and drag, inlet and nacelle weight, and nacelle drag. The use of two data base files to represent the engine and the inlet/nozzle/aftbody performance characteristics is discussed. The existing library of performance characteristics for inlets and nozzle/aftbodies and an example of the 1000 series of engine data tables is presented. A.W.H.

N80-13043*# Boeing Co., Seattle, Wash. Advanced Airplane Branch.

COMPUTER CODE FOR ESTIMATING INSTALLED PERFORMANCE OF AIRCRAFT GAS TURBINE ENGINES. VOLUME 1: FINAL REPORT

Edward J. Kowalski Dec. 1979 204 p refs 3 Vol.
(Contract NAS3-21238)
(NASA-CR-159691; D180-25481-1-Vol-1) Avail: NTIS HC A10/MF A01 CSCL 21E

A computerized method which utilizes the engine performance data is described. The method estimates the installed performance of aircraft gas turbine engines. This installation includes: engine weight and dimensions, inlet and nozzle internal performance and drag, inlet and nacelle weight, and nacelle drag. A.W.H.

N80-13044*# Boeing Co., Seattle, Wash. Advanced Airplane Branch.

COMPUTER CODE FOR ESTIMATING INSTALLED PERFORMANCE OF AIRCRAFT GAS TURBINE ENGINES. VOLUME 2: USERS MANUAL

Edward J. Kowalski Dec. 1979 444 p 3 Vol.
(Contract NAS3-21238)
(NASA-CR-159692; D180-25481-2-Vol-2) Avail: NTIS HC A19/MF A01 CSCL 21E

A computerized method which utilizes the engine performance data and estimates the installed performance of aircraft gas turbine engines is presented. This installation includes: engine weight and dimensions, inlet and nozzle internal performance and drag, inlet and nacelle weight, and nacelle drag. A user oriented description of the program input requirements, program output, deck setup, and operating instructions is presented. A.W.H.

N80-13048*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.

ADVANCED CATALYTIC COMBUSTORS FOR LOW POLLUTANT EMISSIONS, PHASE 1 Final Report

W. J. Dodds Nov. 1979 159 p refs Sponsored in part by Air Force Engineering Services Center, Tyndall AFB, Fla.
(Contract NAS3-20820)
(NASA-CR-159535; CEEDO-TR-79-03) Avail: NTIS HC A08/MF A01 CSCL 21E

The feasibility of employing the known attractive and distinguishing features of catalytic combustion technology to reduce nitric oxide emissions from gas turbine engines during ejector performance. These characteristic points determined which of nine possible ejector configurations provided optimal performance at any given flight and injected gas conditions. Detailed examination of the thermodynamic cycle was made for representative cases and data was presented to illustrate the influence of ejectors upon conventional gas generator performance. The influence of nozzle loss, skin friction and flow separation, incomplete kinetic and thermal mixing, and boundary layer ingestion were taken into consideration in the analysis. Correlation with existing stationary solid and jet-diffuser ejector experiments showed excellent agreement between theory and experiment. It has been shown that ejectors designed according to the methods described, can provide large improvement in propulsion system performance throughout the entire practical flight regime. GRA

N80-14115*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) ACOUSTIC AND AERODYNAMIC TESTS ON A SCALE MODEL OVER-THE-WING THRUST REVERSER AND FORWARD THRUST NOZZLE

D. L. Stimpert 18 Jan. 1978 85 p refs
(Contract NAS3-18021)
(NASA-CR-135254; R75AEG504) Avail: NTIS HC A05/MF A01 CSCL 21E

An acoustic and aerodynamic test program was conducted on a 1/6.25 scale model of the Quiet, Clean, Short-Haul Experimental Engine (QCSEE) forward thrust over-the-wing (OTW) nozzle and OTW thrust reverser. In reverse thrust, the effect of reverser geometry was studied by parametric variations in blocker spacing, blocker height, lip angle, and lip length. Forward thrust nozzle tests determined the jet noise levels of the cruise and takeoff nozzles, the effect of opening side doors to achieve takeoff thrust, and scrubbing noise of the cruise and takeoff jet on a simulated wing surface. Velocity profiles are presented for both forward and reverse thrust nozzles. An estimate of the reverse thrust was made utilizing the measured centerline turning angle. Author

N80-14116*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). UNDER-THE-WING (UTW) ENGINE BOILERPLATE NACELLE TEST REPORT. VOLUME 2: AERODYNAMICS AND PERFORMANCE

31 Dec. 1977 61 p refs
(Contract NAS3-18021)
(NASA-CR-135250; R77AEG2122-Vol-2) Avail: NTIS HC A04/MF A01 CSCL 21E

The initial phase of testing of the under the wing engine and boilerplate nacelle components is discussed. The aerodynamics and performance are outlined. M.M.M.

N80-14117*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.

QUIET, CLEAN, SHORT-HAUL, EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) ENGINE ACOUSTIC DESIGN

H. D. Sowers and W. E. Coward Jan. 1978 62 p refs
(Contract NAS3-18021)
(NASA-CR-135267; R76AEG195) Avail: NTIS HC A04/MF A01 CSCL 21E

The acoustic considerations involved in the low source noise basic engine design and the design procedures followed in the development of the under-the-wing (UTW) engine boilerplate and composite nacelle acoustic treatment designs are presented. Laboratory experiments, component tests, and scale model and engine tests supporting the UTW engine acoustic design are referenced. Acoustic design features include a near-sonic inlet, low fan and core pressure ratios, low fan tip speed, high and low frequency stacked core treatment, multiple thickness treatment, and fan frame and stator vane treatment. R.E.S.

N80-14118*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.

QUIET, CLEAN, SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) ENGINE ACOUSTIC DESIGN

H. D. Sowers and W. E. Coward Jun. 1978 58 p refs
(Contract NAS3-18021)
(NASA-CR-135268; R76AEG228) Avail: NTIS HC A04/MF A01 CSCL 21E

The acoustic considerations involved in the low source noise basic engine design and the design procedures followed in the development of the over-the-wing (OTW) nacelle acoustic treatment design are presented. Laboratory experiments, component tests, and scale model and engine tests supporting the OTW engine acoustic design are referenced. Acoustic design features include a near-sonic inlet, low fan and core pressure ratios, low fan tip speed, high and low frequency stacked core treatment, multiple thickness treatment, and fan frame and stator vane treatment. R.E.S.

N80-14119*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) GRAPHITE/PMR COWL DEVELOPMENT
C. L. Ruggles Jul. 1978 75 p refs
(Contract NAS3-18021)
(NASA-CR-135279; R78AEG206) Avail: NTIS HC A04/MF A01 CSCL 21E

The PMR process development, tooling concepts, testing conducted to generate materials properties data, and the fabrication of a subscale model of the inner cowl are presented. It was concluded that the materials, processes, and tooling concepts were satisfactory for making an inner cowl with adequate structural integrity. M.M.M.

N80-14120*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEM TEST REPORT. VOLUME 2: AERODYNAMICS AND PERFORMANCE
Jul. 1978 49 p refs
(Contract NAS3-18021)
(NASA-CR-135324; R77AEG474-Vol-2) Avail: NTIS HC A03/MF A01 CSCL 21E

The design and testing of the over the wing engine, a high bypass, geared turbofan engine, are discussed. The propulsion system performance is examined for uninstalled performance and installed performance. The fan aerodynamic performance and the D nozzle and reverser thrust performance are evaluated. A.W.H.

N80-14122*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
FEASIBILITY OF SiC COMPOSITE STRUCTURES FOR 1644 K (2500 F) GAS TURBINE SEAL APPLICATION Final Report, 28 Apr. - 30 May 1979
R. Darolia Nov. 1979 120 p ref
(Contract NAS3-20082)
(NASA-CR-159597; R79AEG625) Avail: NTIS HC A06/MF A01 CSCL 21E

The silicon carbide composites evaluated consisted of Si/SiC and sintered silicon carbide as substrates, both with attached surface layers containing BN as an additive. A total of twenty-eight candidates with variations in substrate type and density, and layer chemistry, density, microstructure, and thickness were evaluated for abradability, cold particle erosion resistance, static oxidation resistance, ballistic impact resistance, and fabricability. BN-free layers with variations in density and pore size were later added for evaluation. The most promising candidates were evaluated for Mach 1.0 gas oxidation/erosion resistance from 1477 K (2200 F) to 1644 K (2500 F). The as-fabricated rub layers did not perform satisfactorily in the gas oxidation/erosion tests. However, preoxidation was found to be beneficial in improving the hot gas erosion resistance. Overall, the laboratory and rig test evaluations show that material properties are suitable for 1477 K (2200 F) gas turbine seal applications. Further improvements are needed in hot gas erosion resistance and abradability to demonstrate feasibility to 1644 K (250 F). A.R.H.

N80-14127*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
THE CF6 JET ENGINE PERFORMANCE IMPROVEMENT: NEW FRONT MOUNT
W. A. Fasching Dec. 1979 139 p refs
(Contract NAS3-20629)
(NASA-CR-159639; R79AEG366) Avail: NTIS HC A07/MF A01 CSCL 21E

The New Front Mount was evaluated in component tests including stress, deflection/distortion and fatigue tests. The test results demonstrated a performance improvement of 0.1% in cruise sfc, 16% in compressor stall margin and 10% in compressor stator angle margin. The New Front Mount hardware successfully completed 35,000 simulated flight cycles endurance testing. Author

N80-14129*# Detroit Diesel Allison, Indianapolis, Ind.
STUDY OF TURBOPROP SYSTEMS RELIABILITY AND MAINTENANCE COSTS Final Report
Jun. 1978 304 p refs
(Contract NAS3-20057)
(NASA-CR-135192; EDR-9132) Avail: NTIS HC A14/MF A01 CSCL 21E

The overall reliability and maintenance costs (R&MC's) of past and current turboprop systems were examined. Maintenance cost drivers were found to be scheduled overhaul (40%), lack of modularity particularly in the propeller and reduction gearbox, and lack of inherent durability (reliability) of some parts. Comparisons were made between the 501-D13/54H60 turboprop system and the widely used JT8D turbofan. It was found that the total maintenance cost per flight hour of the turboprop was 76% higher than that of the JT8D turbofan. Part of this difference was due to propeller and gearbox costs being higher than those of the fan and reverser, but most of the difference was in the engine core where the older technology turboprop core maintenance costs were nearly 70 percent higher than for the turbofan. The estimated maintenance cost of both the advanced turboprop and advanced turbofan were less than the JT8D. The conclusion was that an advanced turboprop and an advanced turbofan, using similar cores, will have very competitive maintenance costs per flight hour. J.M.S.

N80-14130*# Avco Lycoming Div., Williamsport, Pa.
EXHAUST EMISSION REDUCTION FOR INTERMITTENT COMBUSTION AIRCRAFT ENGINES
R. N. Moffett Oct. 1979 114 p
(Contract NAS3-19754)
(NASA-CR-159757) Avail: NTIS HC A06/MF A01 CSCL 21E

Three concepts for optimizing the performance, increasing the fuel economy, and reducing exhaust emission of the piston aircraft engine were investigated. High energy-multiple spark discharge and spark plug tip penetration, ultrasonic fuel vaporization, and variable valve timing were evaluated individually. Ultrasonic fuel vaporization did not demonstrate sufficient improvement in distribution to offset the performance loss caused by the additional manifold restriction. High energy ignition and revised spark plug tip location provided no change in performance or emissions. Variable valve timing provided some performance benefit; however, even greater performance improvement was obtained through induction system tuning which could be accomplished with far less complexity. A.R.H.

N80-14182*# Acurex Corp., Mountain View, Calif. Autodata Div.
PHASE-LOCKED TELEMETRY SYSTEM FOR ROTARY INSTRUMENTATION OF TURBOMACHINERY, PHASE 1 Final Report
Alan Adler and Bas Hoeks Sep. 1978 192 p
(Contract NAS3-20290; Acurex Proj. 6497)
(NASA-CR-159453; Acurex-78-284) Avail: NTIS HC A09/MF A01 CSCL 09F

A telemetry system for use in making strain and temperature measurements on the rotating components of high speed turbomachines employs phase locked transmitters, which offer greater measurement channel capacity and reliability than existing systems which employ L-C carrier oscillators. A prototype transmitter module was tested at 175 C combined with 40,000 g's acceleration. A.R.H.

N80-15100*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) COMPOSITE NACELLE SUBSYSTEM TEST REPORT
C. L. Stotler, Jr., E. A. Johnston, and D. S. Freeman Jul. 1977 83 p refs
(Contract NAS3-18021)
(NASA-CR-135075; R76AEG420) Avail: NTIS HC A05/MF A01 CSCL 21E

The element and subcomponent testing conducted to verify the under the wing composite nacelle design is reported. This composite nacelle consists of an inlet, outer cowl doors, inner cowl doors, and a variable fan nozzle. The element tests provided the mechanical properties used in the nacelle design. The subcomponent tests verified that the critical panel and joint areas of the nacelle had adequate structural integrity. J.M.S.

N80-15101*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). BALL SPLINE PITCH CHANGE MECHANISM DESIGN REPORT
Apr. 1978 73 p refs
(Contract NAS3-18021)
(NASA-CR-134873; R77AEG327) Avail: NTIS HC A04/MF A01 CSCL 21E

Detailed design parameters are presented for a variable-pitch change mechanism. The mechanism is a mechanical system containing a ball screw/spline driving two counteracting master bevel gears meshing pinion gears attached to each of 18 fan blades. R.E.S.

N80-15102*# General Electric Co., Cincinnati, Ohio.
ACOUSTIC ANALYSIS OF AFT NOISE REDUCTION TECHNIQUES MEASURED ON A SUBSONIC TIP SPEED 50.8 cm (TWENTY INCH) DIAMETER FAN
D. L. Stimpert and A. Clemons Jan. 1977 149 p refs
(Contract NAS3-18021)
(NASA-CR-134891; R75AEG368) Avail: NTIS HC A07/MF A01 CSCL 21E

Sound data which were obtained during tests of a 50.8 cm diameter, subsonic tip speed, low pressure ratio fan were analyzed. The test matrix was divided into two major investigations: (1) source noise reduction techniques; and (2) aft duct noise reduction with acoustic treatment. Source noise reduction techniques were investigated which include minimizing second harmonic noise by varying vane/blade ratio, variation in spacing, and lowering the Mach number through the vane row to lower fan broadband noise. Treatment in the aft duct which includes flow noise effects, faceplate porosity, rotor OGV treatment, slant cell treatment, and splitter simulation with variable depth on the outer wall and constant thickness treatment on the inner wall was investigated. Variable boundary conditions such as variation in treatment panel thickness and orientation, and mixed porosity combined with variable thickness were examined. Significant results are reported. R.C.T.

N80-15103*# Curtiss-Wright Corp., Wood-Ridge, N.J. Power Systems.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) MAIN REDUCTION GEARS TEST PROGRAM Final Report
O. W. Misel Mar. 1977 220 p refs
(Contract NAS3-18021)
(NASA-CR-134669; CW-WR-77-008) Avail: NTIS HC A10/MF A01 CSCL 21E

Sets of under the wing (UTW) engine reduction gears and sets of over the wing (OTW) engine reduction gears were fabricated for rig testing and subsequent installation in engines. The UTW engine reduction gears which have a ratio of 2.465:1 and a design rating of 9712 kW at 3157 rpm fan speed were operated at up to 105% s feed at 60% torque and 100% speed at 125% torque. The OTW engine reduction gears which have a ratio of 2.062:1 and a design rating of 12,615 kW at 3861 rpm fan speed were operated at up to 95% speed at 50% torque and 80% speed at 109% torque. Satisfactory operation was demonstrated at powers up to 12,172 kW, mechanical efficiency up to 99.1% UTW, and a maximum gear pitch line velocity of 112 m/s (22,300 fpm) with a corresponding star gear spherical roller bearing DN of 850,00 OTW. Oil and star gear bearing temperatures, oil churning, heat rejection, and vibratory characteristics were acceptable for engine installation. R.C.T.

N80-15104*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) CLEAN COMBUSTOR TEST REPORT
Oct. 1975 66 p refs
(Contract NAS3-18021)
(NASA-CR-134916; R75AEG449) Avail: NTIS HC A04/MF A01 CSCL 21E

A component pressure test was conducted on a F101 PFRT combustor to evaluate the emissions levels of this combustor design at selected under the wing and over the wing operating conditions for the quiet clean short haul experimental engine (QCSEE). Emissions reduction techniques were evaluated which included compressor discharge bleed and sector burning in the combustor. The results of this test were utilized to compare the expected QCSEE emissions levels with the emission goals of the QCSEE engine program. R.C.T.

N80-15105*# Curtiss-Wright Corp., Wood-Ridge, N.J.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) MAIN REDUCTION GEARS BEARING DEVELOPMENT PROGRAM Final Report
Dec. 1975 40 p
(Contract NAS3-18021)
(NASA-CR-134890) Avail: NTIS HC A03/MF A01 CSCL 21E

The viability of proposed bearing designs to operate at application conditions is described. Heat rejection variables were defined for the test conditions. Results indicate that there is potential for satisfactory operation of spherical roller bearing in the QCSEE main reduction gear application. R.C.T.

N80-15106*# Curtiss-Wright Corp., Wood-Ridge, N.J.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) MAIN REDUCTION GEARS DETAILED DESIGN REPORT Final Report
A. Defeo and M. Kulina Jul. 1977 221 p
(Contract NAS3-18021)
(NASA-CR-134872; CW-WR-77-024) Avail: NTIS HC A10/MF A01 CSCL 21E

Lightweight turbine engines with geared slower speed fans are considered. The design of two similar but different gear ratio, minimum weight, epicyclic star configuration main reduction gears for the under the wing (UTW) and over the wing (OTW) engines is discussed. The UTW engine reduction gear has a ratio of 2.465:1 and a 100% power design rating of 9885 kW (13,256 hp) at 3143 rpm fan speed. The OTW engine reduction gear has a ratio of 2.062:1 and a 100% power design rating of 12813 kW (17183 hp) at 3861 rpm fan speed. Details of configuration, stresses, deflections, and lubrication are presented. J.M.S.

N80-15107*# Hamilton Standard, Windsor Locks, Conn. Aircraft Systems Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE): HAMILTON STANDARD CAM/HARMONIC DRIVE VARIABLE PITCH FAN ACTUATION SYSTEM DETAIL DESIGN REPORT

Mar. 1976 159 p
(Contract NAS3-18021)
(NASA-CR-134852; HSER-7001) Avail: NTIS
HC A08/MF A01 CSCL 21E

A variable pitch fan actuation system was designed which incorporates a remote nacelle-mounted blade angle regulator. The regulator drives a rotating fan-mounted mechanical actuator through a flexible shaft and differential gear train. The actuator incorporates a high ratio harmonic drive attached to a multitrack spherical cam which changes blade pitch through individual cam follower arms attached to each blade trunnion. Detail design parameters of the actuation system are presented. These include the following: design philosophies, operating limits, mechanical, hydraulic and thermal characteristics, mechanical efficiencies, materials, weights, lubrication, stress analyses, reliability and failure analyses. Author

N80-15108*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE COMPOSITE FAN BLADE DESIGN REPORT Final Report
R. Ravenhall and C. T. Salemme Feb. 1977 61 p refs
(Contract NAS3-18021)
(NASA-CR-135046; R77AEG177) Avail: NTIS
HC A04/MF A01 CSCL 21E

A total of 38 quiet clean short haul experimental engine under the wing composite fan blades were manufactured for various component tests, process and tooling, checkout, and use in the QCSEE UTW engine. The component tests included frequency characterization, strain distribution, bench fatigue, platform static load, whirligig high cycle fatigue, whirligig low cycle fatigue, whirligig strain distribution, and whirligig overspeed. All tests were successfully completed. All blades planned for use in the engine were subjected to and passed a whirligig proof spin test. R.C.T.

N80-15109*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE): THE AERODYNAMIC AND MECHANICAL DESIGN OF THE QCSEE UNDER-THE-WING FAN
Mar. 1977 144 p
(Contract NAS3-18021)
(NASA-CR-135009; R75AEG484) Avail: NTIS
HC A07/MF A01 CSCL 21E

The design, fabrication, and testing of two experimental high bypass geared turbofan engines and propulsion systems for short haul passenger aircraft are described. The aerodynamic and mechanical design of a variable pitch 1.34 pressure ratio fan for the under the wing (UTW) engine are included. The UTW fan was designed to permit rotation of the 18 composite fan blades into the reverse thrust mode of operation through both flat pitch and stall pitch directions. R.C.T.

N80-15110*# General Electric Co., Cincinnati, Ohio.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) COMPOSITE FAN FRAME DESIGN REPORT
S. C. Mitchell Sep. 1978 97 p refs
(Contract NAS3-18021)
(NASA-CR-135278; R77AEG439) Avail: NTIS
HC A04/MF A01 CSCL 21E

An advanced composite frame which is flight-weight and integrates the functions of several structures was developed for the over the wing (OTW) engine and for the under the wing (UTW) engine. The composite material system selected as the basic material for the frame is Type AS graphite fiber in a Hercules 3501 epoxy resin matrix. The frame was analyzed using a finite element digital computer program. This program was used in an iterative fashion to arrive at practical thicknesses and ply orientations to achieve a final design that met all strength and stiffness requirements for critical conditions. Using this information, the detail design of each of the individual parts of the frame was completed and released. On the basis of these designs, the required tooling was designed to fabricate the various component parts of the frame. To verify the structural integrity of the critical joint areas, a full-scale test was conducted on the frame before engine testing. The testing of the frame established critical spring constants and subjected the frame to three critical load cases. The successful static load test was followed by 153 and 58 hours respectively of successful running on the UTW and OTW engines. J.M.S.

N80-15111*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UTW FAN PRELIMINARY DESIGN
Feb. 1975 107 p
(Contract NAS3-18021)
(NASA-CR-134842; R75AEG213) Avail: NTIS
HC A06/MF A01 CSCL 21E

High bypass geared turbofan engines and propulsion systems designed for short-haul passenger aircraft are described. The propulsion technology required for future externally blown flap aircraft with engines located both under the wing and over the wing is emphasized. The aerodynamic and mechanical preliminary design of the QCSEE under the wing 1.34 pressure ratio fan with variable blade pitch is presented. Design information is given for two pitch change actuation systems which will provide reverse thrust. J.M.S.

N80-15112*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE): THE AERODYNAMIC AND PRELIMINARY MECHANICAL DESIGN OF THE QCSEE OTW FAN
Feb. 1975 80 p
(Contract NAS3-18021)
(NASA-CR-134841; R75AEG381) Avail: NTIS
HC A05/MF A01 CSCL 21E

The aerodynamic and mechanical preliminary design of the QCSEE over the wing 1.36 pressure ratio fan is presented. Design information is given for both the experimental and flight designs. J.M.S.

N80-15113*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE COMPOSITE FAN BLADE DESIGN
May 1975 57 p
(Contract NAS3-18021)
(NASA-CR-134840; R75AEG278) Avail: NTIS
HC A04/MF A01 CSCL 21E

The design and analysis of a composite fan blade for the under the wing (UTW) QCSEE is presented. The blade is designed for a variable pitch, 18 bladed rotor and is constructed from a hybrid composite combination of materials consisting of Kevlar-49, type AS graphite, boron, and S-glass fibers in a PR288 epoxy resin matrix. The blade has an attached platform which is constructed of AS-graphite, PR278 epoxy resin matrix and aluminum honeycomb. The blade is designed to satisfy aerostability and cyclic life and strength requirements with a light weight construction. The attached platform is designed for a fail-safe condition in that it is retainable by the blade, under centrifugal force loading, even in the event of blade to platform bond separation. Details of the blade design and the results of stress, vibration, and impact analysis are included. J.M.S.

N80-15114*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING ENGINE AND CONTROL SIMULATION RESULTS
Oct. 1978 107 p refs
(Contract NAS3-18021)
(NASA-CR-135049; R76AEG218) Avail: NTIS
HC A06/MF A01 CSCL 21E

A hybrid computer simulation of the over the wing turbofan engine was constructed to develop the dynamic design of the control This engine and control system includes a full authority digital electronic control using compressor stator reset to achieve fast thrust response and a modified Kalman filter to correct for sensor failures Fast thrust response for powered-lift operations and accurate, fast responding, steady state control of the engine is provided Simulation results for throttle bursts from 62 to 100 percent takeoff thrust predict that the engine will accelerate from 62 to 95 percent takeoff thrust in one second J.M.S.

N80-15115*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) BALL SPLINE PITCH-CHANGE MECHANISM WHIRLIGIG TEST REPORT
Sep 1978 64 p refs
(Contract NAS3-18021)
(NASA-CR-135354; R77AEG394) Avail: NTIS HC A04/MF A01 CSCL 21E
The component testing of a ball spline variable pitch mechanism is described including a whirligig test. The variable pitch actuator successfully completed all planned whirligig tests including a fifty cycle endurance test at actuation rates up to 125 deg per second at up to 102 percent fan speed (3400 rpm). J.M.S.

N80-15116*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) BOILER PLATE NACELLE AND CORE EXHAUST NOZZLE DESIGN REPORT
Oct. 1976 104 p
(Contract NAS3-18021)
(NASA-CR-135008; R76AEG222) Avail: NTIS HC A06/MF A01 CSCL 21E
The mechanical design of the boiler plate nacelle and core exhaust nozzle for the QCSEE under the wing engine is presented. The nacelle, which features interchangeable hard-wall and acoustic panels, is to be utilized in the initial engine testing to establish acoustic requirements for the subsequent composite nacelle as well as in the QCSEE over the wing engine configuration. J.M.S.

N80-15117*# Hamilton Standard, Windsor Locks, Conn.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) WHIRL TEST OF CAM/HARMONIC PITCH CHANGE ACTUATION SYSTEM Contractor Report, 10 Nov. 1975 - 16 Feb. 1976
Apr. 1976 208 p refs
(Contract NAS3-18021)
(NASA-CR-135140; HSER-7002) Avail: NTIS HC A10/MF A01 CSCL 21E
A variable pitch fan actuation system, which incorporates a remote nacelle mounted blade angle regulator, was tested. The regulator drives a rotating fan mounted mechanical actuator through a flexible shaft and differential gear train. The actuator incorporates a high ratio harmonic drive attached to a multitrack spherical cam which changes blade pitch through individual cam follower arms attached to each blade trunnion. Testing of the actuator on a whirl rig, is reported. Results of tests conducted to verify that the unit satisfied the design requirements and was structurally adequate for use in an engine test are presented. J.M.S.

N80-15118*# General Electric Co., Cincinnati, Ohio.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEMS TEST REPORT. VOLUME 4: ACOUSTIC PERFORMANCE
D. L. Stimpert Feb. 1979 144 p refs
(Contract NAS3-18021)
(NASA-CR-135326; R77AEG476-Vol-4) Avail: NTIS HC A07/MF A01 CSCL 21E
A series of acoustic tests were conducted on the over the wing engine These tests evaluated the fully suppressed noise levels in forward and reverse thrust operation and provided insight into the component noise sources of the engine plus the suppression achieved by various components. System noise levels using the contract specified calculation procedure indicate that the in-flight noise level on a 152 m sideline at takeoff and approach are 97.2 and 94.6 EPNdB, respectively, compared to a goal of 95.0 EPNdB. In reverse thrust, the system noise level was 106.1 PNdB compared to a goal of 100 PNdB. Baseline source noise levels agreed very well with pretest predictions. Inlet-radiated noise suppression of 14 PNdB was demonstrated with the high throat Mach number inlet at 0.79 throat Mach number. R.E.S.

N80-15119*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) COMPOSITE NACELLE Final Design Report
E. A. Johnston Aug. 1978 128 p
(Contract NAS3-18021)
(NASA-CR-135352; R77AEG588) Avail: NTIS HC A07/MF A01 CSCL 21E
The detail design of the under the wing experimental composite nacelle components is summarized. Analysis of an inlet, fan bypass duct doors, core cowl doors, and variable fan nozzle are given. The required technology to meet propulsion system performance, weight, and operational characteristics is discussed. The materials, design, and fabrication technology for quiet propulsion systems which will yield installed thrust to weight ratios greater than 3.5 to 1 are described. R.C.T.

N80-15120*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) Final Report
William S. Willis Aug. 1979 408 p refs
(Contract NAS3-18021)
(NASA-CR-159473; R79AEG478) Avail: NTIS HC A18/MF A01 CSCL 21E
The design, fabrication, and testing of two experimental propulsion systems for powered lift transport aircraft are given. The under the wing (UTW) engine was intended for installation in an externally blown flap configuration and the over the wing (OTW) engine for use in an upper surface blowing aircraft. The UTW engine included variable pitch composite fan blades, main reduction gear, composite fan frame and nacelle, and a digital control system. The OTW engine included a fixed pitch fan, composite fan frame, boilerplate nacelle, and a full authority digital control. Many acoustic, pollution, performance, and weight goals were demonstrated. R.C.T.

N80-15121*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). DOUBLE-ANNULAR CLEAN COMBUSTOR TECHNOLOGY DEVELOPMENT REPORT
D. W. Bahr, D. L. Burrus, and P. E. Sabla May 1979 149 p refs
(Contract NAS3-18021)
(NASA-CR-159483; R79AEG397) Avail: NTIS HC A07/MF A01 CSCL 21E
A sector combustor technology development program was conducted to define an advanced double annular dome combustor sized for use in the quiet clean short haul experimental engine (QCSEE). A design which meets the emission goals, and combustor performance goals of the QCSEE engine program was developed. Key design features were identified which resulted in substantial reduction in carbon monoxide and unburned hydrocarbon emission levels at ground idle operating conditions, in addition to very low nitric oxide emission levels at high power operating conditions. Their significant results are reported. R.C.T.

N80-15122*# General Electric Co., Cincinnati, Ohio Aircraft Engine Group
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE): ACOUSTIC TREATMENT DEVELOPMENT AND DESIGN
Art Clemons May 1979 353 p refs
(Contract NAS3-18021)
(NASA-CR-135266; R76AEG379-1) Avail NTIS HC A16/MF A01 CSCL 21E

Acoustic treatment designs for the quiet clean short-haul experimental engines are defined. The procedures used in the development of each noise-source suppressor device are presented and discussed in detail. A complete description of all treatment concepts considered and the test facilities utilized in obtaining background data used in treatment development are also described. Additional supporting investigations that are complementary to the treatment development work are presented. The expected suppression results for each treatment configuration are given in terms of delta SPL versus frequency and in terms of delta PNdB. R.E.S.

N80-15123*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QSCEE). PRELIMINARY ANALYSES AND DESIGN REPORT, VOLUME 1
Oct. 1974 372 p
(Contract NAS3-18021)
(NASA-CR-134838; R74AEG479-Vol-1) Avail: NTIS HC A16/MF A01 CSCL 21E

The experimental propulsion systems to be built and tested in the 'quiet, clean, short-haul experimental engine' program are presented. The flight propulsion systems are also presented. The following areas are discussed: acoustic design; emissions control; engine cycle and performance; fan aerodynamic design; variable-pitch actuation systems; fan rotor mechanical design; fan frame mechanical design; and reduction gear design. R.E.S.

N80-15124*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). PRELIMINARY ANALYSES AND DESIGN REPORT, VOLUME 2
Oct. 1974 330 p
(Contract NAS3-18021)
(NASA-CR-134839; R74AEG479-Vol-2) Avail: NTIS HC A15/MF A01 CSCL 21E

The experimental and flight propulsion systems are presented. The following areas are discussed: engine core and low pressure turbine design; bearings and seals design; controls and accessories design; nacelle aerodynamic design; nacelle mechanical design; weight; and aircraft systems design. R.E.S.

N80-15125*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEM TEST REPORT. VOLUME 1: SUMMARY REPORT
Jan. 1978 67 p
(Contract NAS3-18021)
(NASA-CR-135323; R77AEG473-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 21E

Sea level, static, ground testing of the over-the-wing engine and boilerplate nacelle components was performed. The equipment tested and the test facility are described. Summaries of the instrumentations, the chronological history of the tests, and the test results are presented. R.E.S.

N80-15126*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE WING (OTW) PROPULSION SYSTEM TEST REPORT. VOLUME 3: MECHANICAL PERFORMANCE
Feb 1978 121 p
(Contract NAS3-18021)
(NASA-CR-135325; R77AEG475-Vol-3) Avail NTIS HC A06/MF A01 CSCL 21E

The mechanical performance of the over-the-wing engine is described with emphasis on the advanced technology components. The overall dynamic response of the engine was excellent. R.E.S.

N80-15130*# Yale Univ., New Haven, Conn. Dept. of Engineering and Applied Science
THEORY OF DEPOSITION OF CONDENSIBLE IMPURITIES ON SURFACES IMMERSED IN COMBUSTION GASES Semiannual Report, 15 Jan. - 14 Jul. 1979
Daniel E. Rosner 1979 11 p refs
(Grant NsG-3107)
(NASA-CR-159716; SAR-6) Avail NTIS HC A02/MF A01 CSCL 21E

The components resulting from the deposition of inorganic salts (e.g., Na2SO4) and oxides present in the combustion products from gas turbine engines were investigated. Emphasis was placed on the effects of multicomponent vapor transport, thermophoretic transport of vapor and small particles to actively cooled surfaces, variable fluid properties within mass transfer boundary layers, and free stream turbulence. R.C.T.

N80-15131*# Yale Univ., New Haven, Conn. High Temperature Chemical Reaction Engineering Lab.
EXPERIMENTAL STUDIES OF THE FORMATION/DEPOSITION OF SODIUM SULFATE IN/FROM COMBUSTION GASES Semiannual Report, 15 May - 15 Dec. 1979
Daniel E. Rosner Dec. 1979 10 p refs
(Grant NsG-3169)
(NASA-CR-159753; SAR-4) Avail: NTIS HC A02/MF A01 CSCL 21E

An optical polarization (ellipsometric) technique was developed for measuring rapidly growing and evaporating transparent liquid condensate films (e.g., boric oxide) on solid surfaces exposed to combustion product gases. Results for the B2O3 deposition rate from BCl3-seeded propane/air flames are shown to agree well with the results of earlier interference measurements, and also with theoretical CVD predictions. Evaporation rates (from platinum ribbons into seeded propane air flames) are estimated using the polarization technique. It appears that, compared with the interference method, the polarization technique places less stringent requirements on surface quality, which may justify the added optical components needed for such measurements. It is concluded that the complementary optical methods of polarization (ellipsometry) and interference hold considerable promise for application to the rapid measurement of condensation and evaporation rates in high temperature (e.g., combustion product) environments. A.R.H.

N80-15083*# General Electric Co., Washington, D. C. Aircraft Engine Group.
DEMONSTRATION OF SHORT-HAUL AIRCRAFT AFT NOISE REDUCTION TECHNIQUES ON A TWENTY INCH (50.8 cm) DIAMETER FAN, VOLUME 1
D. L. Stimpert and R. A. McFalls May 1975 131 p refs 3 Vol.
(Contract NAS3-18021)
(NASA-CR 134849; R75AEG252-Vol-1) Avail: NTIS HC A07/MF A01 CSCL 21E

Tests of a 20 inch diameter, low tip speed, low pressure ratio fan which investigated aft fan noise reduction techniques are reported. These techniques included source noise reduction features of selection of vane-blade ratio to reduce second harmonic noise, spacing effects, and lowering the Mach number through a vane row. Aft suppression features investigated included porosity effects, variable depth treatment, and treatment regenerated flow noise. Initial results and selected comparisons are presented. J.M.S.

N80-15084*# General Electric Co., Washington, D. C. Aircraft Engine Group
DEMONSTRATION OF SHORT HAUL AIRCRAFT AFT NOISE REDUCTION TECHNIQUES ON A TWENTY INCH (50.8) DIAMETER FAN, VOLUME 2
D. L. Stimpert Apr. 1975 307 p 3 Vol
(Contract NAS3-18021)
(NASA-CR-134850; R75AEG252-Vol-2) Avail: NTIS HC A14/MF A01 CSCL 21E

Aft fan noise reduction techniques were investigated. The 1/3 octave band sound data were plotted with the following plots included: perceived noise level vs acoustic angle at 2 fan speeds, PWL vs frequency at 2 fan speeds, and sound pressure level vs frequency at 2 aft angles and 2 fan speeds. The source noise plots included: band pass filter sound pressure level vs acoustic angle at 2 fan speeds, and 2nd harmonic SPL acoustic angle at 2 fan speeds. R.C.T.

N80-15085*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group
DEMONSTRATION OF SHORT HAUL AIRCRAFT AFT NOISE REDUCTION TECHNIQUES ON A TWENTY INCH (50.8 cm) DIAMETER FAN, VOLUME 3
D. L. Stimpert Apr. 1975 725 p 3 Vol
(Contract NAS3-18021)
(NASA-CR-134851; R75AEG252-Vol-3) Avail: NTIS HC A99/MF A01 CSCL 21E

Tests of a twenty inch diameter, low tip speed, low pressure ratio fan which investigated aft fan noise reduction techniques are reported. The 1/3 octave band sound data are presented for all the configurations tested. The model data are presented on 17 foot arc and extrapolated to 200 foot sideline. J.M.S.

N80-15086*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER THE WING (OTW) DESIGN REPORT Final Report
Jun. 1977 530 p
(Contract NAS3-18021)
(NASA-CR-134848; R75AEG443) Avail: NTIS HC A23/MF A01 CSCL 21E

The design, fabrication, and testing of two experimental high bypass geared turbofan engines and propulsion systems for short haul passenger aircraft are described. The propulsion technology required for future externally blown flap aircraft with engines located both under the wing and over the wing is demonstrated. ... position are among the parameters investigated. Straight and swept wing configurations were tested across a range of nozzle pressure ratios, lift coefficients, and Mach numbers. F.O.S.

N80-15099*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) BOILERPLATE NACELLE DESIGN REPORT
May 1977 78 p
(Contract NAS3-18021)
(NASA-CR-135168; R77AEG300) Avail: NTIS HC A05/MF A01 CSCL 21E

A summary of the mechanical design of the boiler plate nacelle for the QCSEE over the wing (OTW) engine is presented. The nacelle, which features a D-shaped nozzle/thrust reverser and interchangeable hard wall and acoustic panels, is utilized in the engine testing to establish the aerodynamic and acoustic requirements for nozzles and reversers of this type. J.M.S.

N80-15100*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) COMPOSITE NACELLE SUBSYSTEM TEST REPORT
C. L. Stotler, Jr., E. A. Johnston, and D. S. Freeman Jul. 1977 83 p refs
(Contract NAS3-18021)
(NASA-CR-135075; R76AEG420) Avail: NTIS HC A05/MF A01 CSCL 21E

The element and subcomponent testing conducted to verify the under the wing composite nacelle design is reported. This composite nacelle consists of an inlet, outer cowl doors, inner cowl doors, and a variable fan nozzle. The element tests provided the mechanical properties used in the nacelle design. The subcomponent tests verified that the critical panel and joint areas of the nacelle had adequate structural integrity. J.M.S.

N80-15088*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) PRELIMINARY UNDER THE WING FLIGHT PROPULSION SYSTEM ANALYSIS REPORT
D. F. Howard Feb. 1976 261 p refs
(Contract NAS3-18021)
(NASA-CR-134868; R75AEG349) Avail: NTIS HC A12/MF A01 CSCL 21E

The preliminary design and installation of high bypass, geared turbofan engine with a composite nacelle forming the propulsion system for a short haul passenger aircraft are described. The technology required for externally blown flap aircraft with under the wing (UTW) propulsion system installations for introduction into passenger service in the mid 1980's is included. The design, fabrication, and testing of this UTW experimental engine containing the required technology items for low noise, fuel economy, with composite structure for reduced weight and digital engine control are provided. R.C.T.

N80-15089*# General Electric Co., Cincinnati, Ohio. Group Engineering Div.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). THE AERODYNAMIC AND MECHANICAL DESIGN OF THE QCSEE OVER-THE-WING FAN
Apr. 1976 98 p
(Contract NAS3-18021)
(NASA-CR-134915) Avail: NTIS HC A05/MF A01 CSCL 21E

The aerodynamic and mechanical design of a fixed-pitch 1.36 pressure ratio fan for the over-the-wing (OTW) engine is presented. The fan has 28 blades. Aerodynamically, the fan blades were designed for a composite blade, but titanium blades were used in the experimental fan as a cost savings measure. R.E.S.

N80-15090*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE DIGITAL CONTROL SYSTEM DESIGN REPORT
Jan. 1978 321 p refs
(Contract NAS3-18021)
(NASA-CR-134920; R75AEG483) Avail: NTIS HC A14/MF A01 CSCL 21E

A digital electronic control was combined with conventional hydromechanical components to operate the four controlled variables on the under-the-wing engine: fuel flow, fan blade pitch, fan exhaust area, and core compressor stator angles. The engine and control combination offers improvements in noise, pollution, thrust response, operational monitoring, and pilot workload relative to current engines. R.E.S.

N80-15091*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE SIMULATION REPORT
Jul. 1977 103 p refs
(Contract NAS3-18021)
(NASA-CR-134914; R75AEG444) Avail: NTIS HC A06/MF A01 CSCL 21E

Hybrid computer simulations of the under-the-wing engine were constructed to develop the dynamic design of the controls. The engine and control system includes a variable pitch fan and a digital electronic control. Simulation results for throttle bursts from 62 to 100 percent net thrust predict that the engine will accelerate 62 to 95 percent net thrust in one second. R.E.S.

N80-15092*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING CONTROL SYSTEM DESIGN REPORT
Dec. 1977 249 p refs
(Contract NAS3-18021)
(NASA-CR-135337; R77AEG664) Avail: NTIS HC A11/MF A01 CSCL 21E

A control system incorporating a digital electronic control was designed for the over-the-wing engine. The digital electronic control serves as the primary controlling element for engine fuel flow and core compressor stator position. It also includes data monitoring capability, a unique failure indication and corrective action feature, and optional provisions for operating with a new type of servovalve designed to operate in response to a digital-type signal and to fail with its output device hydraulically locked into position. R.E.S.

N80-15093*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). CORE ENGINE NOISE MEASUREMENTS
H. D. Sowers and W. E. Coward Dec. 1977 52 p ref
(Contract NAS3-18021)
(NASA-CR-135160; R75AEG511) Avail: NTIS HC A04/MF A01 CSCL 21E

Noise measurements were taken on a turbofan engine which uses the same core, with minor modifications, employed on the quiet clean short-haul experimental engine (QCSEE) propulsion systems. Both nearfield and farfield noise measurements were taken in order to determine the core internally generated noise levels. The resulting noise measurements were compared to predicted combustor and turbine noise levels, to verify or improve the predicted QCSEE combustor and turbine noise levels. Author

N80-15094*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Engineering Div.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) ENGINE COMPOSITE NACELLE TEST REPORT. VOLUME 1: SUMMARY, AERODYNAMIC AND MECHANICAL PERFORMANCE
Apr. 1979 214 p refs
(Contract NAS3-18021)
(NASA-CR-159471; R78AEG573-Vol-1) Avail: NTIS HC A10/MF A01 CSCL 21E

The performance test results of the final under-the-wing engine configuration are presented. One hundred and six hours of engine operation were completed, including mechanical and performance checkout, baseline acoustic testing with a bellmouth inlet, reverse thrust testing, acoustic technology tests, and limited controls testing. The engine includes a variable pitch fan having advanced composite fan blades and using a ball-spline pitch actuation system. R.E.S.

N80-15095*# General Electric Co., Cincinnati, Ohio. Group Engineering Div.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) PRELIMINARY OVER-THE-WING FLIGHT PROPULSION SYSTEM ANALYSIS REPORT
D. F. Howard Jun. 1977 174 p refs
(Contract NAS3-18021)
(NASA-CR-135296; R77AEG305) Avail: NTIS HC A08/MF A01 CSCL 21E

The preliminary design of the over-the-wing flight propulsion system installation and nacelle component and systems design features of a short-haul, powered lift aircraft are presented. Economic studies are also presented and show that high bypass, low pressure ratio turbofan engines have the potential of providing an economical propulsion system for achieving the very quiet aircraft noise level of 95 EPNdB on a 152.4 m sideline. R.E.S.

N80-15096*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). UNDER-THE-WING (UTW) ENGINE BOILERPLATE NACELLE TEST REPORT, VOLUME 1 Summary Report
31 Dec. 1977 65 p 3 Vol.
(Contract NAS3-18021)
(NASA-CR-135249; R77AEG212I-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 21E

The design and testing of high bypass geared turbofan engines with nacelles forming the propulsion system for short haul passenger aircraft are considered. The test results demonstrate the technology required for externally blown flap aircraft for introduction into passenger service in the 1980's. The equipment tested is described along with the test facility and instrumentation. A chronological history of the test and a summary of results are given. J.M.S.

N80-15097*# General Electric Co., Cincinnati, Ohio. Advanced Engneering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). UNDER-THE-WING (UTW) ENGINE BOILERPLATE NACELLE TEST REPORT. VOLUME 3: MECHANICAL PERFORMANCE
31 Dec. 1977 128 p refs 3 Vol.
(Contract NAS3-18021)
(NASA-CR-135251; R77AEG212-Vol-3) Avail: NTIS HC A07/MF A01 CSCL 21E

Results of initial tests of the under the wing experimental engine and boilerplate nacelle are presented. The mechanical performance of the engine is reported with emphasis on the advanced technology components. Technology elements of the propulsion system covered include: system dynamics, composite fan blades, reduction gear, lube and accessory drive system, fan frame, inlet, core cowl cooling, fan exhaust nozzle, and digital control system. J.M.S.

N80-15098*# General Electric Co., Cincinnati, Ohio.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). COMPOSITE FAN FRAME SUBSYSTEM TEST REPORT
C. L. Stotler, Jr. and J. H. Bowden Sep. 1977 71 p
(Contract NAS3-18021)
(NASA-CR-135010; R76AEG233) Avail: NTIS HC A04/MF A01 CSCL 21E

The element and subcomponent testing conducted to verify the composite fan frame design of two experimental high bypass geared turbofan engines and propulsion systems for short haul passenger aircraft is described. Emphasis is placed on the propulsion technology required for future externally blown flap aircraft with engines located both under the wing and over the wing, including technology in composite structures and digital engine controls. The element tests confirmed that the processes used in the frame design would produce the predicted mechanical properties. The subcomponent tests verified that the detail Composite structures and digital engine controls are among the topics included. R.C.T.

N80-15099*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) BOILERPLATE NACELLE DESIGN REPORT
May 1977 78 p
(Contract NAS3-18021)
(NASA-CR-135168; R77AEG300) Avail: NTIS HC A05/MF A01 CSCL 21E

A summary of the mechanical design of the boiler plate nacelle for the QCSEE over the wing (OTW) engine is presented. The nacelle, which features a D-shaped nozzle/thrust reverser and interchangeable hard wall and acoustic panels, is utilized in the engine testing to establish the aerodynamic and acoustic requirements for nozzles and reversers of this type. J.M.S.

N80-16061*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
CORE NOISE INVESTIGATION OF THE CF6-50 TURBOFAN ENGINE Data Report, 1978 - 1979
V. L. Doyle Jan. 1980 357 p
(Contract NAS3-21260)
(NASA-CR-159598; R79AEG247) Avail: NTIS HC A16/MF A01 CSCL 21E

Acoustic data obtained during the running of the CF6-50 turbofan engine on an outdoor test stand are presented. The test was conducted to acquire simultaneous internal and far-field measurements to determine the influence of internally generated noise on the far-field measurements. The data includes internal and far-field narrowband and one-third octave band pressure spectra. R.E.S.

N80-16062*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
CORE NOISE INVESTIGATION OF THE CF6-50 TURBOFAN ENGINE Final Report
V. L. Doyle and M. T. Moore Jan. 1980 520 p refs
(Contract NAS3-21260)
(NASA-CR-159749; R79AEG395) Avail: NTIS HC A22/MF A01 CSCL 21E

The contribution of the standard production annular combustor to the far-field noise signature of the CF6-50 engine was investigated. Internal source locations were studied. Transfer functions were determined for selected pairs of combustor sensors and from two internal sensors to the air field. The coherent output power was determined in the far-field measurements, and comparisons of measured overall power level were made with component and engine correlating parameters. R.E.S.

N80-16063*# Pratt and Whitney Aircraft Group, East Hartford, Conn.
EXPANDED STUDY OF FEASIBILITY OF MEASURING IN-FLIGHT 747/JT9D LOADS, PERFORMANCE, CLEARANCE, AND THERMAL DATA
G. P. Sallee and R. L. Martin (Boeing Commercial Airplane Co., Seattle, Wash.) 4 Feb. 1980 107 p
(Contract NAS3-20632)
(NASA-CR-159717; PWA-5512-46) Avail: NTIS HC A06/MF A01 CSCL 21E

The JT9D jet engine exhibits a TSFC loss of about 1 percent in the initial 50 flight cycles of a new engine. These early losses are caused by seal-wear induced opening of running clearances in the engine gas path. The causes of this seal wear have been identified as flight induced loads which deflect the engine cases and rotors, causing the rotating blades to rub against the seal surfaces, producing permanent clearance changes. The real level of flight loads encountered during airplane acceptance testing and revenue service and the engine's response in the dynamic flight environment were investigated. The feasibility of direct measurement of these flight loads and their effects by concurrent measurement of 747/JT9D propulsion system aerodynamic and inertia loads and the critical engine clearance and performance changes during 747 flight and ground operations was evaluated. A number of technical options were examined in relation to the total estimated program cost to facilitate selection of the most cost effective option. It is concluded that a flight test program meeting the overall objective of determining the levels of aerodynamic and inertia load levels to which the engine is exposed during the initial flight acceptance test and normal flight maneuvers is feasible and desirable. A specific recommended flight test program, based on the evaluation of cost effectiveness, is defined. A.R.H.

N80-17073*# Pratt and Whitney Aircraft Group, West Palm Beach, Fla.
DISTRIBUTION ANALYSIS FOR F100(3) ENGINE Final Report
W. A. Walter and M. Shaw Jan. 1980 66 p refs
(Contract NAS3-20835)
(NASA-CR-159754; FR-12087) Avail: NTIS HC A04/MF A01 CSCL 21E

The F100(3) compression system response to inlet circumferential distortion was investigated using an analytical compressor flow model. Compression system response to several types of distortion, including pressure, temperature, and combined pressure/temperature distortions, was investigated. The predicted response trends were used in planning future F100(3) distortion tests. Results show that compression system response to combined temperature and pressure distortions depends upon the relative orientation, as well as the individual amplitudes and circumferential extents of the distortions. Also the usefulness of the analytical predictions in planning engine distortion tests is indicated. J.M.S.

N80-17074*# Pratt and Whitney Aircraft, East Hartford, Conn.
EXPERIMENTAL EVALUATION OF A LOW EMISSIONS HIGH PERFORMANCE DUCT BURNER FOR VARIABLE CYCLE ENGINES (VCE) Final Report
R. P. Lohmann and R. J. Mador Oct. 1979 118 p refs
(Contract NAS3-20602)
(NASA-CR-159694; PWA-5513-32A) Avail: NTIS HC A06/MF A01 CSCL 21A

An evaluation was conducted with a three stage Vorbix duct burner to determine the performance and emissions characteristics of the concept and to refine the configuration to provide acceptable durability and operational characteristics for its use in the variable cycle engine (VCE) testbed program. The tests were conducted at representative takeoff, transonic climb, and supersonic cruise inlet conditions for the VSCE-502B study engine. The test stand, the emissions sampling and analysis equipment, and the supporting flow visualization rigs are described. The performance parameters including the fuel-air ratio, the combustion efficiency/exit temperature, thrust efficiency, and gaseous emissions calculations are defined. The test procedures are reviewed and the results are discussed. A.W.H.

N80-18040*# Little (Arthur D.), Inc., Cambridge, Mass.
STUDY OF RESEARCH AND DEVELOPMENT REQUIREMENTS OF SMALL GAS-TURBINE COMBUSTORS
E. P. Demetri, R. F. Topping, and R. P. Wilson, Jr. Jan. 1980 69 p refs
(Contract NAS3-21980)
(NASA-CR-159796; ADL-83381-2) Avail: NTIS HC A04/MF A01 CSCL 21E

A survey is presented of the major small-engine manufacturers and governmental users. A consensus was undertaken regarding small-combustor requirements. The results presented are based on an evaluation of the information obtained in the course of the study. The current status of small-combustor technology is reviewed. The principal problems lie in liner cooling, fuel injection, part-power performance, and ignition. Projections of future engine requirements and their effect on the combustor are discussed. The major changes anticipated are significant increases in operating pressure and temperature levels and greater capability of using heavier alternative fuels. All aspects of combustor design are affected, but the principal impact is on liner durability. An R&D plan which addresses the critical combustor needs is described. The plan consists of 15 recommended programs for achieving necessary advances in the areas of liner thermal design, primary-zone performance, fuel injection, dilution, analytical modeling, and alternative-fuel utilization. M.M.M.

N80-18041*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
INTERNAL COATING OF AIR COOLED GAS TURBINE BLADES Final Report
P. L. Ahuja Nov. 1979 73 p refs

(Contract NAS3-21038)
(NASA-CR-159701) Avail NTIS HC A04/MF A01 CSCL 21E

Six coating systems were evaluated for internal coating of decent stage (DS) eutectic high pressure turbine blades. Sequential deposition of electroless Ni by the hydrazine process, slurry Cr, and slurry Al, followed by heat treatment provided the coating composition and thickness for internal coating of DS eutectic turbine blades. Both NiCr and NiCrAl coating compositions were evaluated for strain capability and ductile to brittle transition temperature. R.C.T.

N80-18042*# Vought Corp., Dallas, Tex.
LOW SPEED TEST OF THE AFT INLET DESIGNED FOR A TANDEM FAN V/STOL NACELLE
W. W. Rhoades and A. H. Ybarra Feb. 1980 79 p refs
(Contract NAS3-21468)
(NASA-CR-159752; TR-2-30320/OR-52360) Avail: NTIS HC A05/MF A01 CSCL 21E

An approximately .25 scale model of a Tandem Fan nacelle designed for a Type A V/STOL aircraft configuration was tested in a 10-by-10 foot wind tunnel. A 12 inch, tip driven, turbofan simulator was used to provide the suction source for the aft fan inlet. The front fan inlet was faired over for this test entry. Model variables consisted of a long aft inlet cowl, a short aft inlet cowl, a shaft simulator, blow-in door passages and diffuser vortex generators. Inlet pressure recovery, distortion, inlet angle of attack separation limits were evaluated at tunnel velocities from 0 to 240 knots, angles of attack from -10 to 40 degrees and inlet flow rates representative of throat Mach numbers of 0.1 to 0.6. High inlet performance and stable operation was verified at all design forward speed and angle of attack conditions. The short aft inlet configuration provided exceptionally high pressure recovery except at the highest combination of angle of attack and forward speed. The flow quality at the fan face was somewhat degraded by the addition of blow-in door passages to the long aft inlet configuration due to the pressure disturbances generated by the flow entering the diffuser through the auxiliary air passages. M.M.M.

N80-19113*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
CORE COMPRESSOR EXIT STAGE STUDY. 1: AERODYNAMIC AND MECHANICAL DESIGN
E. A. Burdsall, E. Canal, Jr., and K. A. Lyons Sep. 1979 128 p ref
(Contract NAS3-20578)
(NASA-CR-159714; PWA-5561-55) Avail: NTIS HC A07/MF A01 CSCL 21E

The effect of aspect ratio on the performance of core compressor exit stages was demonstrated using two three stage, highly loaded, core compressors. Aspect ratio was identified as having a strong influence on compressors endwall loss. Both compressors simulated the last three stages of an advanced eight stage core compressor and were designed with the same 0.915 hub/tip ratio, 4.30 kg/sec (9.47 1bm/sec) inlet corrected flow, and 167 m/sec (547 ft/sec) corrected mean wheel speed. The first compressor had an aspect ratio of 0.81 and an overall pressure ratio of 1.357 at a design adiabatic efficiency of 88.3% with an average diffusion factor or 0.529. The aspect ratio of the second compressor was 1.22 with an overall pressure ratio of 1.324 at a design adiabatic efficiency of 88.7% with an average diffusion factor of 0.491. R.C.T.

N80-20271*# Teledyne Continental Motors, Muskegon, Mich.
A 150 AND 300 kW LIGHTWEIGHT DIESEL AIRCRAFT ENGINE DESIGN STUDY Final Report
Alex P. Brouwers Apr. 1980 149 p refs
(Contract NAS3-20830)
(NASA-CR-3260; Rept-756) Avail: NTIS HC A07/MF A01 CSCL 21A

The diesel engine was reinvestigated as an aircraft powerplant through design study conducted to arrive at engine configurations and applicable advanced technologies. Two engines are discussed, a 300 kW six-cylinder engine for twin engine general aviation aircraft and a 150 kW four-cylinder engine for single engine aircraft. Descriptions of each engine include concept drawings, a performance analysis, stress and weight data, and a cost study. This information was used to develop two airplane concepts, a six-place twin and a four-place single engine aircraft. The aircraft study consists of installation drawings, computer generated performance data, aircraft operating costs, and drawings of the resulting airplanes. The performance data show a vast improvement over current gasoline-powered aircraft. R.E.S.

N80-21328*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
PROGRAM FOR IMPACT TESTING OF SPAR-SHELL FAN BLADES, TEST REPORT
R. Ravenhall and C. T. Salemme Apr. 1978 95 p
(Contract NAS3-20801)
(NASA-CR-135393; R78AEG444) Avail: NTIS HC A05/MF A01 CSCL 21E

Six filament-wound, composite spar-shell fan blades were impact tested in a whirligig relative to foreign object damage resulting from ingestion of birds into the fan blades of a QCSEE-type engine. Four of the blades were tested by injecting a simulated two pound bird into the path of the rotating blade and two were tested by injecting a starling into the path of the blade. R.E.S.

N80-21329*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
MANUFACTURE OF LOW CARBON ASTROLOGY TURBINE DISK SHAPES BY HOT ISOSTATIC PRESSING, VOLUME 2, PROJECT 1 Final Report
R. D. Eng and D. J. Evans Jan. 1979 10 p
(Contract NAS3-20072)
(NASA-CR-135410; PWA-5574-37) Avail: NTIS HC A02/MF A01 CSCL 21E

The performance of a hot isotatic pressed disk installed in an experimental engine and exposed to realistic operating conditions in a 150-hour engine test and a 1000 cycle endurance test is documented. Post test analysis, based on visual, fluorescent penetrant and dimensional inspection, revealed no defects in the disk and indicated that the disk performed satisfactorily. R.E.S.

N80-21330*# IIT Research Inst., Chicago, Ill.
THERMAL FATIGUE AND OXIDATION DATA FOR DIRECTIONALLY SOLIDIFIED MAR-M 246 TURBINE BLADES
V. L. Hill and V. E. Humphreys Jan. 1980 45 p refs
(Contract NAS3-19696)
(NASA-CR-159798; IITRI-M6003-53) Avail: NTIS HC A03/MF A01 CSCL 21E

Thermal fatigue and oxidation data were obtained for 11 plasma spray coated and 13 uncoated directionally solidified and single crystal MAR-M 246 blades. Blade coatings on the airfoil included several metal-oxide thermal barrier layers based on Al_2O_3, Cr_2O_3, or ZrO_2. The 24 turbine blades were tested simultaneously for 3000 cycles in fluidized beds maintained at 950 and 25 C using a symmetrical 360 set thermal cycle. In 3000 cycles, only uncoated turbine blades exhibited cracking on the trailing edge near the platform; 3 of the 13 uncoated blades did not crack. Cracking occurred over the range 400 to 2750 cycles, with single crystal blades indicating the poorest thermal fatigue resistance. Oxidation of the uncoated blades was limited in 3000 cycles. All coatings indicated microscopically visible spalling at the trailing edge radius after 3000 cycles. Severe general spalling on the airfoil was observed for two multilayered coatings. Author

N80-21331*# AiResearch Mfg. Co., Phoenix, Ariz.
AIRESEARCH QCGAT PROGRAM Final Report
R. W. Heldenbrand and W. M. Norgren 10 Jan. 1979 199 p refs
(Contract NAS3-20585)
(NASA-CR-159758; AIRESEARCH-21-3071) Avail: NTIS

HC A09/MF A01 CSCL 21E

A model TFE731-1 engine was used as a baseline for the NASA quiet clean general aviation turbofan engine and engine/nacelle program designed to demostrate the applicability of large turbofan engine technology to small general aviation turbofan engines, and to obtain significant reductions in noise and pollutant emissions while reducing or maintaining fuel consumption levels. All new technology design for rotating parts and all items in the engine and nacelle that contributed to the acoustic and pollution characteristics of the engine system were of flight design, weight, and construction. The major noise, emissions, and performance goals were met. Noise levels estimated for the three FAR Part 36 conditions, are 10 to 15 ENPdB below FAA requirements; emission values are considerably reduced below that of current technology engines; and the engine performance represents a TSFC improvement of approximately 9 percent over other turbofan engines. A.R.H.

N80-21332*# Pratt and Whitney Aircraft Group, East Hartford, Conn.

DEVELOPMENT OF IMPROVED HIGH PRESSURE TURBINE OUTER GAS PATH SEAL COMPONENTS Progress Report, Dec. 1976 - Oct. 1979

Lawrence T. Shiembob Jan. 1980 80 p

(Contract NAS3-20590)

(NASA-CR-159801; PWA-5568) Avail: NTIS HC A05/MF A01 CSCL 21E

A plasma sprayed graded layered ceramic/metallic (ZrO2/CoCrAlY) seal was evaluated for JT9D turbine application by rig and engine tests. Four cyclic thermal shock rig tests were conducted during the program. Three completed 1000 simulated engine thermal cycle tests and the fourth completed 500 cycles without severe cracking or spalling. Three ceramic seals were installed in a JT9D experimental engine to evaluate the effect of the engine thermal environment on the seals. All three seals completed the test successfully without severe cracking or spalling. The three seals did have slight laminar cracks at the 85/15-40/60 ZrO2/CoCrAlY interface. The second engine test evaluated the rub capabilities of the seal. Six ceramic seals were installed in the engine with fourteen abrasive tip blades. Three of the six seals rubbed to a depth of 24 mils. Eight of the fourteen abrasive tip blades showed evidence of wear. Three of the eight blades wore a maximum of five mils. Engine rub test results demonstrated the potential of reducing turbine clearances and thereby improving engine performance by use of sprayed ceramic seals. J.M.S.

N80-21334*# Pratt and Whitney Aircraft Group, West Palm Beach, Fla.

DATA ANALYSIS OF P SUB T/P SUB S NOSEBOOM PROBE TESTING ON F100 ENGINE P680072 AT NASA LEWIS RESEARCH CENTER Final Report

C. H. Foote Mar. 1980 23 p

(Contract NAS3-19442)

(NASA-CR-159816; PWA-FR-12540) Avail: NTIS HC A02/MF A01 CSCL 21E

Results from the altitude testing of a P sub T/P sub S noseboom probe on the F100 engine are discussed. The resultss are consistent with sea level test results. The F100 engine altitude test verified automatic downmatch with the engine pressure ratio control, and backup control inlet case static pressure demonstrated sufficient accuracy for backup control fuel flow scheduling. The production P6 probe measured Station 6 pressures accurately for both undistorted and distorted inlet airflows. M.G.

N80-22323*# Massachusetts Inst. of Tech., Cambridge. Aeroelastic and Structures Research Lab.

TWO-DIMENSIONAL FINITE-ELEMENT ANALYSES OF SIMULATED ROTOR-FRAGMENT IMPACTS AGAINST RINGS AND BEAMS COMPARED WITH EXPERIMENTS

Thomas R. Stagliano, Emmett A. Witmer, and Jose J. A. Rodal Dec. 1979 363 p refs

(Grant NGR-22-009-339)

(NASA-CR-159645; ASRL-TR-154-13) Avail: NTIS HC A16/MF A01 CSCL 21E

Finite element modeling alternatives as well as the utility and limitations of the two dimensional structural response computer code CIVM-JET 4B for predicting the transient, large deflection, elastic plastic, structural responses of two dimensional beam and/or ring structures which are subjected to rigid fragment impact were investigated. The applicability of the CIVM-JET 4B analysis and code for the prediction of steel containment ring response to impact by complex deformable fragments from a trihub burst of a T58 turbine rotor was studied. Dimensional analysis considerations were used in a parametric examination of data from engine rotor burst containment experiments and data from sphere beam impact experiments. The use of the CIVM-JET 4B computer code for making parametric structural response studies on both fragment-containment structure and fragment-deflector structure was illustrated. Modifications to the analysis/computation procedure were developed to alleviate restrictions. E.D.K.

N80-22324*# Pratt and Whitney Aircraft Group, East Hartford, Conn.

PERFORMANCE DETERIORATION BASED ON EXISTING (HISTORICAL) DATA; JT9D JET ENGINE DIAGNOSTICS PROGRAM

G. Phil Sallee 20 Apr. 1978 228 p refs

(Contract NAS3-20632)

(NASA-CR-135448; PWA-5512-21) Avail: NTIS HC A11/MF A01 CSCL 21E

The results of the collection and analysis of historical data pertaining to the deterioration of JT9D engine performance are presented. The results of analyses of prerepair and postrepair engine test stand performance data from a number of airlines to establish the individual as well as average losses in engine performance with respect to service use are included. Analysis of the changes in mechanical condition of parts, obtained by inspection of used gas-path parts of varying age, allowed preliminary assessments of component performance deterioration levels and identification of the causitive factors. These component performance estimates, refined by data from special engine back-to-back testing related to module performance restoration, permitted the development of preliminary models of engine component/module performance deterioration with respect to usage. The preliminary assessment of the causes of module performance deterioration and the trends with usage are explained, along with the role each module plays in overall engine performance deterioration. Preliminary recommendations with respect to operating and maintenance practices which could be adopted to control the level of performance deterioration are presented. The needs for additional component sensitivity testing as well as outstanding issues are discussed. J.M.S.

N80-22325*# Solar Turbines International, San Diego, Calif.

ADVANCED CERAMIC MATERIAL FOR HIGH TEMPERATURE TURBINE TIP SEALS Final Report, Feb. 1976 - May 1979

J. W. Vogan, N. G. Solomon, and A. R. Stetson Jan. 1980 97 p refs

(Contract NAS3-20081)

(NASA-CR-159774; SR79-R-4482-43; RDR-1831-43) Avail: NTIS HC A05/MF A01 CSCL 11A

Forty-one material systems were evaluated for potential use in turbine blade tip seal applications at 1370 C. Both ceramic blade tip inserts and abradable ceramic tip shoes were tested. Hot gas erosion, impact resistance, thermal stability, and dynamic rub performance were the criteria used in rating the various materials. Silicon carbide and silicon nitride were used, both as blade tips and abradables. The blade tip inserts were fabricated by hot pressing while low density and honeycomb abradables were sintered or reaction bonded. Author

N80-22326*# Teledyne Continental Motors, Muskegon, Mich.

DESIGN STUDY: A 186 kW LIGHTWEIGHT DIESEL AIRCRAFT ENGINE Final Report

Alex P. Brouwers Apr. 1980 24 p

(Contract NAS3-20830)

(NASA-CR-3261) Avail: NTIS HC A02/MF A01 CSCL 21E

The design of an aircraft engine capable of developing 186 kW shaft power at a 7620 m altitude is described. The 186 kW design takes into account expected new developments in aircraft designs resulting in a reassessment of the power requirements at the cruise mode operation. Based on the results of this analysis a three phase technology development program is projected resulting in production dates of 1985, 1992, and 2000. R.E.S.

N80-22333*# Avco Lycoming Div., Stratford, Conn.
AVCO LYCOMING QUIET CLEAN GENERAL AVIATION TURBOFAN ENGINE
Craig A. Wilson *In* NASA. Lewis Res. Center Gen. Aviation Propulsion Mar. 1980 p 155-187 refs (For primary document see N80-22327 13-07)
Avail NTIS HC A19/MF A01 CSCL 21E

A fan module was developed using an existing turboshaft engine. The fan was designed using the latest in large engine noise control technology. A mixer was added to reduce the already low exhaust gas velocity. A nacelle incorporating sound treatment was provided for the test engine. A noise prediction model was used through the design process to evaluate the various design alternatives. Acoustic tests were then made to development of advances in combustion systems, electronics, materials and control systems. R.E.S.

N80-23309*# General Electric Co., Cincinnati, Ohio.
CF6 JET ENGINE PERFORMANCE IMPROVEMENT: NEW FAN
W. A. Fasching May 1980 202 p
(Contract NAS3-20629)
(NASA-CR-159699; R79AEG413) Avail: NTIS HC A10/MF A01 CSCL 21E

As part of the NASA sponsored engine component improvement program, and fan package was developed to reduce fuel consumption in current CF6 turbofan aircraft engine. The new fan package consist of an improved fan blade, reduced fan tip clearance due to a fan case stiffener, and a smooth fan casing tip shroud. CF6 engine performance and acoustic tests demonstrated the predicted 1.8% improvement in cruise sfc without an increase in engine noise. Power management thrust/fan speed characteristics were defined. Mechanical and structural integrity was demonstrated in model fan rotor photoelastic stress tests, full-size fan blade bench fatigue tests, and CF6 engine bird ingestion, crosswind, and cyclic endurance tests. The fan was certified in the CF6-500c2/E2 engines and is in commerical service on the Boeing 747-200, Douglas DC-10-30, and Atrbus industrie A300B aircraft. A.R.H.

N80-23311*# Hamilton Standard, Windsor Locks, Conn.
ACOUSTIC TEST AND ANALYSES OF THREE ADVANCED TURBOPROP MODELS Final Report
Bennett M. Brooks and F. B. Metzger Jan. 1980 245 p refs
(Contract NAS3-20614)
(NASA-CR-159667) Avail: NTIS HC A11/MF A01 CSCL 21E

Results of acoustic tests of theree 62.2 cm (24.5 inch) diameter models of the prop-fan (a small diameter, highly loaded. Multi-bladed variable pitch advanced turboprop) are presented. Results show that there is little difference in the noise produced by unswept and slightly swept designs. However, the model designed for noise reduction produces substantially less noise at test conditions simulating 0.8 Mach number cruise speed or at conditions simulating takeoff and landing. In the near field at cruise conditions the acoustically designed. In the far field at takeoff and landing conditions the acoustically designed model is 5 db quieter than unswept or slightly swept designs. Correlation between noise measurement and theoretical predictions as well as comparisons between measured and predicted acoustic pressure pulses generated by the prop-fan blades are discussed. The general characteristics of the pulses are predicted. Shadowgraph measurements were obtained which showed the location of bow and trailing waves. R.C.T.

N80-23312*# Pratt and Whitney Aircraft Group, East Hartford, Conn.
CORE COMPRESSOR EXIT STAGE STUDY, 2 Final Report
R. F. Behlke, E. A. Burdsall, E. Canal, Jr., and N. D. Korn Oct. 1979 90 p refs
(Contract NAS3-20578)
(NASA-CR-159812; PWA-5561-66) Avail: NTIS HC A05/MF A01 CSCL 21E

A total of two three-stage compressors were designed and tested to determine the effects of aspect ratio on compressor performance. The first compressor was designed with an aspect ratio of 0.81; the other, with an aspect ratio of 1.22. Both compressors had a hub-tip ratio of 0.915, representative of the rear stages of a core compressor, and both were designed to achieve a 15.0% surge margin at design pressure ratios of 1.357 and 1.324, respectively, at a mean wheel speed of 167 m/sec. At design speed the 0.81 aspect ratio compressor achieved a pressure ratio of 1.346 at a corrected flow of 4.28 kg/sec and an adiabatic efficiency of 86.1%. The 1.22 aspect ratio design achieved a pressure ratio of 1.314 at 4.35 kg/sec flow and 87.0% adiabatic efficiency. Surge margin to peak efficiency was 24.0% with the lower aspect ratio blading, compared with 12.4% with the higher aspect ratio blading. R.C.T.

N80-23315*# Williams Research Corp., Walled Lake, Mich.
CONCEPTUAL DESIGN STUDY OF AN IMPROVED GAS TURBINE POWERTRAIN Final Report
W. I. Chapman Mar. 1980 294 p refs
(Contracts DEN3-12; EC-77-A-31-1040)
(NASA-CR-159852; DOE/NASA/0013-80/1; WRC-78-182)
Avail: NTIS HC A13/MF A01 CSCL 21E

The conceptual design for an improved gas turbine (IGT) powertrain and vehicle was investigated. Cycle parameters, rotor systems, and component technology were reviewed and a dual rotor gas turbine concept was selected and optimized for best vehicle fuel economy. The engine had a two stage centrifugal compressor with a design pressure ratio of 5.28, two axial turbine stages with advanced high temperature alloy integral wheels, variable power turbine nozzle for turbine temperature and output torque control, catalytic combustor, and annular ceramic recuperator. The engine was rated at 54.81 kW, using water injection on hot days to maintain vehicle acceleration. The estimated vehicle fuel economy was 11.9 km/l in the combined driving cycle, 43 percent over the 1976 compact automobile. The estimated IGT production vehicle selling price was 10 percent over the comparable piston engine vehicle, but the improved fuel economy and reduced maintenance and repair resulted in a 9 percent reduction in life cycle cost. R.C.T.

N80-23316*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
CF6-6D ENGINE SHORT-TERM PERFORMANCE DETERIORATION
W. H. Kramer, J. E. Paas, J. J. Smith, and R. H. Wulf Apr. 1980 154 p
(Contract NAS3-20631)
(NASA-CR-159830; R80AEG374) Avail: NTIS HC A08/MF A01

Studies conducted as part of the NASA-Lewis CF6 jet engine diagnostics program are summarized. An 82-engine sample of DC-10-10 aircraft engine checkout data that were gathered to define the extent and magnitude of CF6-6D short term performance deterioration were analyzed. These data are substantiated by the performance testing and analytical teardown of CF6-6D short term deterioration engine serial number (ESN) 451507. R.C.T.

N80-25332*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
ENGINE COMPONENT IMPROVEMENT: PERFORMANCE IMPROVEMENT, JT9D-7 3.8 AR FAN Progress Report, Jan. 1978 - Feb. 1979
W. O. Gaffin 12 Jun. 1980 57 p ref

(Contract NAS3-20630)
(NASA-CR-159806; PWA-5515-114) Avail: NTIS HC A04/MF A01 CSCL 21E

A redesigned, fuel efficient fan for the JT9D-7 engine was tested. Tests were conducted to determine the effect of the 3.8 AR fan on performance, stability, operational characteristics, and noise of the JT9D-7 engine relative to the current 4.6 AR Bill-of-Material fan. The 3.8 AR fan provides increased fan efficiency due to a more advanced blade airfoil with increased chord, eliminating one part span shroud and reducing the number of fan blades and fan exit guide vanes. Engine testing at simulated cruise conditions demonstrated the predicted 1.3 percent improvement in specific fuel consumption with the redesigned 3.8 AR fan. Flight testing and sea level stand engine testing demonstrated exhaust gas temperature margins, fan and low pressure compressor stability, operational suitability, and noise levels comparable to the Bill-of-Material fan. Author

N80-25333*# Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div.
STUDY OF BLADE ASPECT RATIO ON A COMPRESSOR FRONT STAGE Final Report, 28 Oct. 1977 - 28 May 1979
R. F. Behlke, J. D. Brooky, and E. Canal, Jr. Nov. 1980 261 p refs
(Contract NAS3-20809)
(NASA-CR-159556; PWA-5583-58) Avail: NTIS HC A12/MF A01 CSCL 21E

A single stage, low aspect ratio, compressor with a 442.0 m/sec (1450 ft/sec) tip speed and a 0.597 hub/tip ratio typical of an advanced core compressor front stage was tested. The test stage incorporated an inlet duct which was representative of an engine transition duct between fan and high pressure compressors. At design speed, the rotor stator stage achieved a peak adiabatic efficiency of 86.6 percent at a flow of 44.35 kg/sec (97.8 lbm/sec) and a pressure ratio of 1.8. Surge margin was 12.5 percent from the peak stage efficiency point. Author

N80-25335*# Detroit Diesel Allison, Indianapolis, Ind.
EXPERIMENTAL DETERMINATION OF UNSTEADY BLADE ELEMENT AERODYNAMICS IN CASCADES. VOLUME 1: TORSION MODE CASCADE Final Report
R. E. Riffel and M. D. Rothrock Jun. 1980 305 p
(Contract NAS3-20055)
(NASA-CR-159831; EDR-10119-Vol-1) Avail: NTIS HC A14/MF A01 CSCL 21E

A two dimensional cascade of harmonically oscillating airfoils was designed to model a near tip section from a rotor which was known to have experienced supersonic torsional flutter. This five bladed cascade had a solidity of 1.17 and a setting angle of 1.07 rad. Graphite epoxy airfoils were fabricated to achieve the realistically high reduced frequency level of 0.44. The cascade was tested over a range of static pressure ratios approximating the blade element operating conditions of the rotor along a constant speed line which penetrated the flutter boundary. The time-steady and time-unsteady flow field surrounding the center cascade airfoil were investigated. The effects of reduced solidity and decreased setting angle on the flow field were also evaluated. Author

N80-25340*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
PERFORMANCE DETERIORATION BASED ON IN-SERVICE ENGINE DATA: JT9D JET ENGINE DIAGNOSTICS PROGRAM
G. P. Sallee 27 Apr. 1979 185 p refs
(Contract NAS3-20632)
(NASA-CR-159525; PWA-5512-35) Avail: NTIS HC A09/MF A01 CSCL 21E

Results of analyses of engine performance deterioration trends and levels with respect to service usage are presented. Thirty-two JT9D-7A engines were selected for this purpose. The selection of this engine fleet provided the opportunity of obtaining engine performance data starting before the first flight through initial service such that the trend and levels of engine deterioration related to both short and long term deterioration could be more carefully defined. The performance data collected and analyzed included in-flight, on wing (ground), and test stand prerepair and postrepair performance calibrations with expanded instrumentation where feasible. The results of the analyses of these data were used to: (1) close gaps in previously obtained historical data as well as augment the historical data with more carefully obtained data; (2) refine preliminary models of performance deterioration with respect to usage; (3) establish an understanding of the relationships between ground and altitude performance deterioration trends; (4) refine preliminary recommendations concerning means to reduce and control deterioration; and (5) identify areas where additional effort is required to develop an understanding of complex deterioration issues. E.R.

N80-26300*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
EXPERIMENTAL AERODYNAMIC AND ACOUSTIC MODEL TESTING OF THE VARIABLE CYCLE ENGINE (VCE) TESTBED COANNULAR EXHAUST NOZZLE SYSTEM
D. P. Nelson and P. M. Morris 15 Jun. 1980 83 p
(Contract NAS3-20061)
(NASA-CR-159710; PWA-5550-31) Avail: NTIS HC A05/MF A01 CSCL 21E

Aerodynamic performance and jet noise characteristics of a one sixth scale model of the variable cycle engine testbed exhaust system were obtained in a series of static tests over a range of simulated engine operating conditions. Model acoustic data were acquired. Data were compared to predictions of coannular model nozzle performance. The model, tested with and without a hardwall ejector, had a total flow area equivalent to a 0.127 meter (5 inch) diameter conical nozzle with a 0.65 fan to primary nozzle area ratio and a 0.82 fan nozzle radius ratio. Fan stream temperatures and velocities were varied from 422 K to 1089 K (760 R to 1960 R) and 434 to 755 meters per second (1423 to 2477 feet per second). Primary stream properties were varied from 589 to 1089 K (1060 R to 1960 R) and 353 to 600 meters per second (1158 to 1968 feet per second). Exhaust plume velocity surveys were conducted at one operating condition with and without the ejector installed. Thirty aerodynamic performance data points were obtained with an unheated air supply. Fan nozzle pressure ratio was varied from 1.8 to 3.2 at a constant primary pressure ratio of 1.6; primary pressure ratio was varied from 1.4 to 2.4 while holding fan pressure ratio constant at 2.4. Operation with the ejector increased nozzle thrust coefficient 0.2 to 0.4 percent. B.D.

N80-26301*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
EXPERIMENTAL AERODYNAMIC AND ACOUSTIC MODEL TESTING OF THE VARIABLE CYCLE ENGINE (VCE) TESTBED COANNULAR EXHAUST NOZZLE SYSTEM: COMPREHENSIVE DATA REPORT
D. P. Nelson and P. M. Morris Jun. 1980 225 p
(Contract NAS3-20061)
(NASA-CR-159711; PWA-5550-40) Avail: NTIS HC A10/MF A01 CSCL 21E

The component detail design drawings of the one sixth scale model of the variable cycle engine testbed demonstrator exhaust system tested are presented. Also provided are the basic acoustic and aerodynamic data acquired during the experimental model tests. The model drawings, an index to the acoustic data, an index to the aerodynamic data, tabulated and graphical acoustic data, and the tabulated aerodynamic data and graphs are discussed. B.D.

N80-26302*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
CF6 JET ENGINE PERFORMANCE IMPROVEMENT PROGRAM: HIGH PRESSURE TURBINE AERODYNAMIC PERFORMANCE IMPROVEMENT
W. A. Fasching Jul. 1980 156 p refs
(Contract NAS3-20629)
(NASA-CR-159832) Avail: NTIS HC A08/MF A01 CSCL 21E

The improved single shank high pressure turbine design was evaluated in component tests consisting of performance, heat transfer and mechanical tests, and in core engine tests. The instrumented core engine test verified the thermal, mechanical, and aeromechanical characteristics of the improved turbine design. An endurance test subjected the improved single shank turbine to 1000 simulated flight cycles, the equivalent of approximately 3000 hours of typical airline service. Initial back-to-back engine tests demonstrated an improvement in cruise sfc of 1.3% and a reduction in exhaust gas temperature of 10 C. An additional improvement of 0.3% in cruise sfc and 6 C in EGT is projected for long service engines. Author

N80-27361*# Curtiss-Wright Corp., Wood-Ridge, N.J.
PERFORMANCE, EMISSIONS, AND PHYSICAL CHARACTERISTICS OF A ROTATING COMBUSTION AIRCRAFT ENGINE, SUPPLEMENT A
R. K. Lamping, I. Manning, D. Myers, and B. Tjoa May 1980 74 p
(Contract NAS3-20808)
(NASA-CR-135119; CW-WR-76-028.3) Avail: NTIS HC A04/MF A01 CSCL 21E

Testing was conducted using the basic RC2-75 engine, to which several modifications were incorporated which were designed to reduce the hydrocarbon emissions and reduce the specific fuel consumption. The modifications included close-in surface gap spark plugs, increased compression ratio rotors, and provisions for utilizing either side or peripheral intake ports, or a combination of the two if required. The proposed EPA emissions requirements were met using the normal peripheral porting. The specific fuel economy demonstrated for the modified RC2-75 was 283 g/kW-hr at 75% power and 101 brake mean effective pressure (BMEP) and 272.5 g/kW-hr at 75% power and 111 BMEP. The latter would result from rating the engine for takeoff at 285 hp and 5500 rpm, instead of 6000 rpm. E.D.K.

N80-27364*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
CF6-6D ENGINE PERFORMANCE DETERIORATION
Ray H. Wulf, W. H. Kramer, J. E. Pass, and J. J. Smith Jan. 1980 286 p refs
(Contract NAS3-20631)
(NASA-CR-159786; R80AEG218) Avail: NTIS HC A13/MF A01 CSCL 21E

Cruise cockpit recordings and test cell performance data in conjunction with hardware inspection data from airline overhaul shops were analyzed to define the extent and magnitude of performance deterioration of the General Electric CF6-6D model engine. These studies successfully isolated short-term deterioration from the longer term, and defined areas where a significant reduction in aircraft energy requirements for the 1980's can be realized. Unrestored losses which remain after engine refurbishment represent over 70% of the loss at engine shop visit. Sixty-three percent of the unrestored losses are cost-effective to restore which could reduce fuel consumed by CF6-6D engines in 1980 by 10.9 million gallons. Author

N80-29302*# Department of Energy, Washington, D. C.
OUTLOOK FOR ALTERNATIVE ENERGY SOURCES
Michael E. Card *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 5-9 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21D

Predictions are made concerning the development of alternative energy sources in the light of the present national energy situation. Particular emphasis is given to the impact of alternative fuels development on aviation fuels. The future outlook for aircraft fuels is that for the near term, there possibly will be no major fuel changes, but minor specification changes may be possible if supplies decrease. In the midterm, a broad cut fuel may be used if current development efforts are successful. As synfuel production levels increase beyond the 1990's there may be some mixtures of petroleum-based and synfuel products with the possibility of some shale distillate and indirect coal liquefaction products near the year 2000. M.G.

N80-29303*# United Air Lines, Inc., Chicago, Ill.
CURRENT JET FUEL TRENDS
Paul P. Campbell *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 11-14 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21D

Data concerning the properties of commercial jet fuels during a period between 1974 and 1979 are discussed. During this period the average aromatics content of fuels increased from 16% to 17.5%. It is evident that the arrival of Alaska North Slope crude in 1977 had a significant impact upon the aromatics content of jet fuel supply at West Coast points with less effect upon the entire United States domestic market. This increase in aromatics has not been accompanied by a corresponding reduction in burning quality as measured by smoke point. There has been a reduction of .6 smoke point on the average. Looking at hydrogen content as a measure of burning quality, the all refinery average calculated hydrogen for 1978 was approximately 13.7%. The relationship between hydrogen content and aromatics content shows a slope of 043% reduction in hydrogen for 1% increase in aromatics. M.G.

N80-29304*# Boeing Commercial Airplane Co., Seattle, Wash.
AVIATION FUELS OUTLOOK
Albert M. Momenthy *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 15-24 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21D

Options for satisfying the future demand for commercial jet fuels are analyzed. It is concluded that the most effective means to this end are to attract more refiners to the jet fuel market and encourage development of processes to convert oil shale and coal to transportation fuels. Furthermore, changing the U.S. refineries fuel specification would not significantly alter jet fuel availability. M.G.

N80-29305*# California Univ. at Los Angeles. School of Engineering and Applied Science.
A METHODOLOGY FOR LONG-RANGE PREDICTION OF AIR TRANSPORTATION
Mohammad B. Ayati and J. Morley English *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 25-30 refs Presented at the SAE Intern. Air Transportation Meeting, Cincinnati, 20-22 May 1980 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 01C

A framework and methodology for long term projection of demand for aviation fuels is presented. The approach taken includes two basic components. The first was a new technique for establishing the socio-economic environment within which the future aviation industry is embedded. The concept utilized was a definition of an overall societal objective for the very long run future. Within a framework so defined, a set of scenarios by which the future will unfold are then written. These scenarios provide the determinants of the air transport industry operations and accordingly provide an assessment of future fuel requirements. The second part was the modeling of the industry in terms of an abstracted set of variables to represent the overall industry performance on a macro scale. The model was validated by testing the desired output variables from the model with historical data over the past decades. M.G.

N80-29306*# Exxon Research and Engineering Co., Linden, N.J.
EFFECT OF REFINING VARIABLES ON THE PROPERTIES AND COMPOSITION OF JP-5
Martin Lieberman and William F. Taylor *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 31-39 (For primary document see N80-29300 20-07)
(Contract N00140-78-C-1491)
Avail: NTIS HC A11/MF A01 CSCL 21D

Potential future problem areas that could arise from changes in the composition, properties, and potential availability of JP-5 produced in the near future are identified. Potential fuel problems concerning thermal stability, lubricity, low temperature flow, combustion, and the effect of the use of specific additives on fuel properties and performance are discussed. An assessment of available crudes and refinery capabilities is given. M.G.

N80-29307*# Douglas Aircraft Co., Inc., Santa Monica, Calif.
FUEL/ENGINE/AIRFRAME TRADEOFF STUDY, PHASE 1
A. T. Peacock *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 41-47 Sponsored by AF (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21E

The effects of broadening the specifications for JP-4 and JP-8 fueld on the performance and cost of all USAF aircraft presently using JP-4 as well as those expected to be introduced into the force structure by 1983 are investigated. Test results indicated that there was no impact on engine performance, turbine durability, and coking, however there was a small maintenance cost increase as a result of a small combustor life decrease. Using JP-4 as standard fuel will avoid the use of high demand middle distillate fuels and give producers flexibility. Extensive use of JP-8 in the United States will increase middle distillate demand and cause a slight increase in engine hot-section maintenance. It is also concluded that the maximum allowable freeze point of JP-4 or JP-8 cannot be increased without degrading system performance and safety as critical conditions are approached. M.G.

N80-29308*# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.
MILITARY JET FUEL FROM SHALE OIL
Edward N. Coppola *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 49-57 refs (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21D

Investigations leading to a specification for aviation turbine fuel produced from whole crude shale oil are described. Refining methods involving hydrocracking, hydrotreating, and extraction processes are briefly examined and their production capabilities are assessed. M.G.

N80-29311*# General Electric Co., Fairfield, Conn.
EXPERIMENTAL COMBUSTOR STUDY PROGRAM
John M. Kasper and Edward E. Ekstedt *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 75-82 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21E

Advanced combustor concepts are evaluated as a means of accommodating possible future broad specification fuels. The three advanced double annular combustor concepts consisted of (1) a concept employing high pressure drop fuel nozzles for improved atomization, (2) a concept with premixing tubes in the main stage, and (3) a concept with the pilot stage on the inside and the main stage on the sideout, which is the reverse of the other two concepts. All of the advanced concepts show promise for reduced sensitivity to fuel hydrogen content. Some hardware problems were encountered, but these problems could be quickly resolved if refinement tests were conducted. The design with the premixing main stage was selected for a parametric test because of its low NOx emissions level, carbon free dome, and very low dome temperatures which were essentially independent of fuel type. The other advanced designs also had low done temperatures. The premixing dome design liner temperatures exhibited less sensitivity to fuel type than did the base-line combustor, although more sensitivity than observed for concept 1. The inner liner hot spot and the observed smoke results for the premixing design suggest that the fuel-air mixture was not as uniform as desired. M.G.

N80-29312*# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.
FUEL CHARACTER EFFECTS ON THE J79 AND F101 ENGINE COMBUSTION SYSTEMS
Thomas A. Jackson *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 83-93 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21E

The effects of select fuel property variations on two major engine classifications are summarized. Thirteen refined and blended fuels were used which exhibited significant variations in hydrogen content, aromatic type, initial boiling point, final boiling point, and viscosity. Trends were very similar but the degree of fuel sensitivity was not constant. For both systems the dominant fuel property during high pressure operation was found to be fuel hydrogen content. For operation at low pressure test points the fuel volatility and viscosity became the dominant fuel properties for both systems. Aromatic type and final boiling point did not significantly affect combustion data. Correlations of other fuel properties with these and other performance parameters are presented. E.D.K.

N80-29314*# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.
AIR FORCE FUEL MAINBURNER/TURBINE EFFECTS PROGRAMS
Thomas A. Jackson *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 99-103 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21E

A program for the determination of fuel property effects on aircraft gas turbine engine mainburners and turbines is discussed. The six engines selected as test candiates are the J79, J85, J57, TF30, TF39, and F100. Fuels election is the responsibility of the contractors with two fuels as exceptions. The petroleum JP-4 is to be used as a baseline in all tests. The shale JP-4 is to be used in nearly all tests. Fuel properties are to be correlated with combustion system performance paramters. In addition, life predictions are to be made for combustor and turbine hardware. These predictions are to be based on a typical mission for each system, measured metal temperatures and temperature gradients, and oxidation/corrosion effects. E.D.K.

N80-29315*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
THE BROADENED-SPECIFICATION FUELS COMBUSTION TECHNOLOGY PROGRAM AT PRATT AND WHITNEY AIRCRAFT
Robert P. Lohmann *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 105-108 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21B

The impact of the use of broadened specification fuels on combustor design was investigated. Particular emphasis was placed on establishing the viability of various combustor modifications to permit the use of broadened specification fuels while meeting exhaust emissions and performance specifications and maintaining acceptable combustor operational and durability characteristics. Three different combustor concepts will be evaluated. Various design modifications on the operating capability of each of the combustor concepts with experimental referee broadened specification fuel. The modifications that were evaluated included perturbations of the combustor airflow schedules to alter local stoichiometry and residence time histories revisions to the fuel injectors and variations in liner cooling including the use of thermal barrier coatings and/or advanced cooling concepts. R.C.T.

N80-29316*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
NASA/GENERAL ELECTRIC BROAD-SPECIFICATION FUELS COMBUSTION TECHNOLOGY PROGRAM, PHASE 1
Willard J. Dodds *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 109-113 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21D

The use of broad specification fuels in aircraft turbine engine combustion systems was examined. Three different combustor design concepts were evaluated for their ability to use broad specification fuels while meeting several specific emissions, performance, and durability goals. These combustor concepts covered a range from those having limited complexity and relatively low technical risk to those having high potential for achieving all of the program goals at the expense of increased technical risk. R.C.T.

N80-29318*# Purdue Univ., Lafayette, Ind.
ATOMIZATION OF BROAD SPECIFICATION AIRCRAFT FUELS
J. G. Skifstad and A. H. Lefebvre *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 117-124 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21D

The atomization properties of liquid fuels for the potential use in aircraft gas turbine engines are discussed. The significance of these properties are addressed with respect to the ignition and subsequent combustion behavior of the fuel spray/air mixture. It is shown that the fuel properties which affect the atomization behavior (viscosity, surface tension, and density) are less favorable for the broad specification fuels as compared to with those for conventional fuels. R.C.T.

N80-29320*# Massachusetts Inst. of Tech., Cambridge.
SOOT FORMATION AND BURNOUT IN FLAMES
B. Prado, J. D. Bittner, K. Neoh, and J. B. Howard *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 131-137 refs (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21B

The amount of soot formed when burning a benzene/hexane mixture in a turbulent combustor was examined. Soot concentration profiles in the same combustor for kerosene fuel are given. The chemistry of the formation of soot precursors, the nucleation, growth and subsequent burnout of soot particles, and the effect of mixing on the previous steps were considered. R.C.T.

N80-29321*# Exxon Research and Engineering Co., Linden, N.J.
FUEL PROPERTY EFFECTS IN STIRRED COMBUSTORS
In NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 139-146 Sponsored by DOE (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21E

Soot formation in strongly backmixed combustion was investigated using the jet-stirred combustor (JSC). This device provided a combustion volume in which temperature and combustion were uniform. It simulated the recirculating characteristics of the gas turbine primary zone; it was in this zone where mixture conditions were sufficiently rich to produce soot. Results indicate that the JSC allows study of soot formation in an aerodynamic situation revelant to gas turbines. R.C.T.

N80-29322*# Southwest Research Inst., San Antonio, Tex.
EFFECT OF FUEL MOLECULAR STRUCTURE ON SOOT FORMATION IN GAS TURBINE COMBUSTION
D. W. Naegeli and C. A. Moses *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 147-152 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21B

The effect of fuel variations at the same hydrogen content on the formation of soot in a gas turbine combustor was studied. Six fuels were burned to a combustor over a matrix of about 50 test conditions with test conditions ranging over 500-1800 kPa (5-18 atm) pressure and 500-1000 K burner inlet temperature; fuel-air ratios were varied from 0.008-0.024. Flame radiation measurements were made through a sapphire window toward the end of the primary zone. The hydrogen content of the six test fuels ranged from 12.80 to 12.88%. Five fuels emphasized hydrocarbon types: (mono, di, and tricyclic), naphthenes (decalin) and partially hydrogenated aromatics (tetralin); the sixth fuel emphasized final boiling point. R.C.T.

N80-29325*# United Technologies Research Center, East Hartford, Conn.
EXPERIMENTAL STUDY OF TURBINE FUEL THERMAL STABILITY IN AN AIRCRAFT FUEL SYSTEM SIMULATOR
Alexander Vranos and Pierre J. Marteney *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 169-179 ref (For primary document see N80-29300 20-07)
(Contract NAS3-21593)
Avail: NTIS HC A11/MF A01 CSCL 21D

The thermal stability of aircraft gas turbines fuels was investigated. The objectives were: (1) to design and build an aircraft fuel system simulator; (2) to establish criteria for quantitative assessment of fuel thermal degradation; and (3) to measure the thermal degradation of Jet A and an alternative fuel. Accordingly, an aircraft fuel system simulator was built and the coking tendencies of Jet A and a model alternative fuel (No. 2 heating oil) were measured over a range of temperatures, pressures, flows, and fuel inlet conditions. R.C.T.

N80-29326*# Naval Air Propulsion Test Center, Trenton, N.J.
DETERMINATION OF JET FUEL THERMAL DEPOSIT RATE USING A MODIFIED JFTOT
C. J. Nowack and R. J. Delfosse *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 181-184 (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21D

Three fuels having different breakpoint temperatures were studied in the modified jet fuel thermal oxidation tester. The lower stability fuel with a breakpoint of 240 C was first stressed at a constant temperature. After repeating this procedure at several different temperatures, an Arrehenius plot was drawn from the data. The correlation coefficient and the energy of activation were calculated to be 0.97 and 8 kcal/mole respectively. Two other fuels having breakpoint temperatures of 271 C and 285 C were also studied in a similar manner. A straight line was drawn through the data at a slope equivalent to the slope of the lower stability fuel. The deposit formation rates for the three fuels were determined at 260 C, and a relative deposit formation rate at this temperature was calculated and plotted as a function of the individual fuel's breakpoint temperatures. R.C.T.

N80-29327*# Colorado School of Mines, Golden.
MECHANISMS OF NITROGEN HETEROCYCLE INFLUENCE ON TURBINE FUEL STABILITY
Stephen R. Daniel and Jonathan H. Worstell *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 185-193 (For primary document see N80-29300 20-07)
(Contract NsG-3122)
Avail: NTIS HC A11/MF A01 CSCL 21D

Lewis bases were extracted from a Utah COED syncrude via ligand exchange. Addition of this extract to Jet A at levels as low as 5 ppm N produced deterioration of stability in both JFTOT and accelerated storage tests (7 days at 394 K with 13:1 air to fuel ratio). Comparable effects on Jet A stability were obtained by addition of pyridine and quinoline, while pyrrole and indole were less detrimental at the same concentration level. The weight of deposit produced accelerated storage tests was found to be proportional to the concentration of added nitrogen compound. Over the narrow temperature range accessible with the experimental method, Arrhenius plots obtained by assuming specific rate to be proportional to the weight of material deposited in seven days exhibit greater slopes in the presence of those nitrogen compounds producing the greater deposition rates. It is shown that despite variation in appearance the elemental composition and spectral characteristics of the deposits are unaffected by addition of the nitrogen compounds. The linearity of the Arrhenius plots and of a plot of Arrhenius slope versus intercept for all the compounds suggests a constancy of mechanism over the range of temperature and heterocycles studied. R.C.T.

N80-29329*# Boeing Military Airplane Development, Seattle,

Wash.
HIGH-FREEZING-POINT FUEL STUDIES
Frederick F. Tolle *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 205-219 refs (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/MF A01 CSCL 21D

Considerable progress in developing the experimental and analytical techniques needed to design airplanes to accomodate fuels with less stringent low temperature specifications is reported. A computer technique for calculating fuel temperature profiles in full tanks was developed. The computer program is being extended to include the case of partially empty tanks. Ultimately, the completed package is to be incorporated into an aircraft fuel tank thermal analyser code to permit the designer to fly various thermal exposure patterns, study fuel temperatures versus time, and determine holdup. E.D.K.

N80-29297*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) COMPOSITE NACELLE TEST REPORT. VOLUME 2: ACOUSTIC PERFORMANCE
D. L. Stimpert Nov. 1979 124 p refs 2 Vol.
(Contract NAS3-18021)
(NASA-CR-159472; R78AEG-574-Vol-2) Avail: NTIS HC A06/MF A01 CSCL 21E

High bypass geared turbofan engines with nacelles forming the propulsion system for short-haul passenger aircraft were tested for use in externally blown flap-type aircraft. System noise levels for a four-engine, UTW-powered aircraft operating in the powered lift mode were calculated to be 97.2 and 95.7 EPNdB at takeoff and approach, respectively, on a 152.4 m (500 ft) sideline compared to a goal of 95.0 EPNdB. A.R.H.

N80-29298*# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE COMPOSITE FAN BLADE: PRELIMINARY DESIGN TEST REPORT
May 1975 63 p
(Contract NAS3-18021)
(NASA-CR-134846; R75AEG411) Avail: NTIS HC A04/MF A01 CSCL 21E

Results of tests conducted on preliminary design polymeric-composite fan blade for the under the wing (UTW) OCSEE engine are presented. During this phase of the program a total of 17 preliminary OCSEE UTW composite fan blades were manufactured for various component tests including frequency characteristics, strain distribution, bench fatigue, dovetail pull, whirligig overspeed and whirligig impact. All tests were successuflly completed with the exception of whirligig impact tests. Improvements in local impact capability are being evaluated for the OCSEE blade under other NASA and related programs. Author

N80-29299*# General Electric Co., Cincinnati, Ohio.
ACOUSTIC PERFORMANCE OF A 50.8-cm (20-INCH) DIAMETER VARIABLE-PITCH FAN AND INLET. VOLUME 2: ACOUSTIC DATA Final Report
K. R. Bilwakesh, A. Clemons, and D. L. Stimpert Nov. 1979 495 p refs 2 Vol.
(NASA-CR-135118; R77AEG229-Vol-2) Avail: NTIS HC A21/MF A01 CSCL 21E

Results from acoustic tests on a 50.8 cm (20 inch) QCSEE Under-the-Wing (UTW) engine, variable pitch fan and inlet simulator are tabulated. Tests were run in both forward and reverse thrust mdoes with a bellmouth inlet, five accelerating inlets (one hardwall and four treated), and four low Mach number inlets (one hardwall and three treated). The 1/3 octave-band acoustic data are presented for the model size on the measured 5.2 m (17.0 ft) arc and also data scaled to full QCSEE size 71:20 on a 152.4 m (500 ft) sideline. A.R.H.

N80-29330*# Lockheed-California Co., Burbank.
LOW TEMPERATURE FUEL BEHAVIOR STUDIES
Francis J. Stockemer *In* NASA. Lewis Res. Center Aircraft Res. and Technol. for Future Fuels Jul. 1980 p 221-233 refs (For primary document see N80-29300 20-07)
(Contract NAS3-20814)
Avail: NTIS HC A11/MF A01 CSCL 21E

Aircraft fuels at low temperatures near the freezing point. The principal objective was an improved understanding of the flowability and pumpability of the fuels in a facility that simulated the heat transfer and temperature profiles encountered during flight in the long range commercial wing tanks. R.C.T.

N80-29331*# TRW, Inc., Cleveland, Ohio.
TUNGSTEN WIRE/FeCrAlY MATRIX TURBINE BLADE FABRICATION STUDY
P. Melnyk and J. N. Fleck Dec. 1979 99 p refs
(Contract NAS3-20391)
(NASA-CR-159788; TRW-ER-8101) Avail: NTIS HC A05/MF A01 CSCL 21E

The objective was to establish a viable FRS monotape technology base to fabricate a complex, advanced turbine blade. All elements of monotape fabrication were addressed. A new process for incorporation of the matrix, including bi-alloy matrices, was developed. Bonding, cleaning, cutting, sizing, and forming parameters were established. These monotapes were then used to fabricate a 48 ply solid JT9D-7F 1st stage turbine blade. Core technology was then developed and first a 12 ply and then a 7 ply shell hollow airfoil was fabricated. As the fabrication technology advanced, additional airfoils incorporated further elements of sophistication, by introducing in sequence bonded root blocks, cross-plying, bi-metallic matrix, tip cap, trailing edge slots, and impingement inserts. Author

N80-30310*# General Electric Co., Cincinnati, Ohio. Aircraft Business Group.
ENGINE CYCLE STUDIES PROGRAM Final Report, Sep. 1978 - Oct. 1979
R. D. Allan, J. E. Johnson, W. Joy, R. H. Brown, and H. J. Barrial Aug. 1980 176 p refs
(Contract NAS3-21388)
(NASA-CR-159500; R80AEG428) Avail: NTIS HC A09/MF A01 CSCL 21E

The double bypass, variable cycle engine (VCE) used as the propulsion system for a Mach 2.4 cruise supersonic commercial transport was examined in the following areas: (1) the acoustic and performance payoffs of the high flow mode of the double bypass VCE; (2) possible cycle improvements for noise; (3) manufacturing cost, reliability and maintainability of the VCE compared to other engine concepts; (4) an assessment of the performance and economic payoffs of the features used in the double bypass VCE. The high flow capability of the double bypass VCE did show acoustic and performance payoffs both with unsuppressed and with mechanically suppressed coannular exhaust systems. At lower noise goals, changes to the baseline VCE cycle improved takeoff gross weight for a design version by up to 4%. The double bypass feature of the VCE provided performance and acoustic flexibility that resulted in lower takeoff gross weight for all noise levels, utilizing unsuppressed coannular nozzle, suppressed coannular nozzle, and single stream fully suppressed nozzle. The manufacturing cost, reliability, and maintainability of the double bypass VCE compares favorably with the simpler concepts studied (within 1 to 5.5%). L.F.M.

N80-31398*# TRW, Inc., Cleveland, Ohio. Materials Technology.
COST ANALYSIS OF COMPOSITE FAN BLADE MANUFACTURING PROCESSES Final Report
T. S. Stelson and C. F. Barth Jun. 1980 87 p refs
(Contract NAS3-21352)
(NASA-CR-159876; TRW-ER-8064) Avail: NTIS HC A05/MF A01 CSCL 21E

The relative manufacturing costs were estimated for large high technology fan blades prepared by advanced composite fabrication methods using seven candidate materials/process systems. These systems were identified as laminated resin matrix composite, filament wound resin matrix composite, superhybrid solid laminate, superhybrid spar/shell, metal matrix composite, metal matrix composite with a spar and shell, and hollow titanium. The costs were calculated utilizing analytical process models and all cost data are presented as normalized relative values where 100 was the cost of a conventionally forged solid titanium fan blade whose geometry corresponded to a size typical of 42 blades per disc. Four costs were calculated for each of the seven candidate systems to relate the variation of cost on blade size. Geometries typical of blade designs at 24, 30, 36 and 42 blades per disc were used. The impact of individual process yield factors on costs was also assessed as well as effects of process parameters, raw materials, labor rates and consumable items. A.R.H.

N80-33408*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
ENERGY EFFICIENT ENGINE
D. Burrus, P. E. Sabla, and D. W. Bahr Jun. 1980 118 p refs
(Contract NAS3-20643)
(NASA-CR-159685; R79AEG562) Avail: NTIS HC A06/MF A01 CSCL 21E

The feasibility of meeting or closely approaching the emissions goals established for the Energy Efficient Engine (E3) Project with an advanced design, single annular combustor was determined. A total of nine sector combustor configurations and one full-annular-combustor configuration were evaluated. Acceptable levels of carbon monoxide and hydrocarbon emissions were obtained with several of the sector combustor configurations tested, and several of the configurations tested demonstrated reduced levels of nitrogen oxides compared to conventional, single annular designs. None of the configurations tested demonstrated nitrogen oxide emission levels that meet the goal of the E3 Project. Author

A80-27737 * # **Laser anemometer measurements at the exit of a T63 combustor.** D. R. Zimmerman (General Motors Corp., Detroit Diesel Allison Div., Indianapolis, Ind.). In: Flow in primary, non-rotating passages in turbomachines; Proceedings of the Winter Annual Meeting, New York, N.Y., December 2-7, 1979. (A80-27732 10-02) New York, American Society of Mechanical Engineers, 1979, p. 57-62. 9 refs. Research supported by the General Motors Corp.; Contract No. NAS3-21267.

In the first practical application of laser anemometry to an actual gas turbine engine combustor, the mean velocity and turbulent intensity profiles were measured in a steady-flow combustion rig across an annulus simulating a turbine inlet; to establish a basis for comparison with similar measurements to be made in an operating engine and to confirm current turbine aerodynamics and heat transfer design assumptions. It was necessary to develop a new experimental technique for traversing the annulus due to differential thermal expansion of the cantilevered combustion rig and a new computer-graphics analysis technique for analyzing the velocity histograms due to the high background light intensity. The axial mean velocity and turbulent intensity were uniform across the annulus under all operating conditions and the flow had little or no swirl component. The isothermal mean velocity was doubled by the burning of fuel, however, the isothermal turbulent intensity was relatively unaffected. (Author)

A80-35958 * # **Acoustic measurements of three Prop-Fan models.** B. M. Brooks (United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.). *American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 6th, Hartford, Conn., June 4-6, 1980, Paper 80-0995.* 13 p. 16 refs. Contract No. NAS3-20614.

Results of NASA sponsored acoustic tests of three 2 ft. diameter models of the Prop-Fan (a small diameter, highly loaded, many-bladed variable pitch advanced turboprop) are presented. The highly swept model designed for noise reduction produces substantially less near field noise at simulated 0.8 Mach number cruise conditions than the unswept or slightly swept models. It also produces less far field noise at conditions simulating takeoff and landing. The noise reduction mechanism is discussed. Correlation between harmonic noise measurements and theoretical predictions and between measured and predicted acoustic pressure pulses is good. Shadowgraph measurements which show the location of blade associated wave patterns were obtained. Predicted and measured wave locations show good general agreement. Full scale near and far field noise is predicted. (Author)

A80-38982 * # **Multifuel rotary aircraft engine.** C. Jones and M. Berkowitz (Curtiss-Wright Corp., Wood-Ridge, N.J.). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1237.* 15 p. 17 refs. Contract No. NAS3-21285.

The broad objectives of this paper are the following: (1) to summarize the Curtiss-Wright design, development and field testing background in the area of rotary aircraft engines; (2) to briefly summarize past activity and update development work in the area of stratified charge rotary combustion engines; and (3) to discuss the development of a high-performance direct injected unthrottled stratified charge rotary combustion aircraft engine. Efficiency improvements through turbocharging are also discussed. S.D.

A80-41506 * # **Fuel conservation through active control of rotor clearances.** R. S. Beitler, A. A. Saunders, and R. P. Wanger (General Electric Co., Aircraft Engine Group, Evendale, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1087.* 8 p. Contract No. NAS3-20643.

Under the NASA-sponsored Energy Efficient Engine (EEE) Project, technology is being developed which will significantly reduce the fuel consumption of turbofan engines for subsonic transport aircraft. One technology concept being pursued is active control of rotor tip clearances. Attention is given to rotor tip clearance considerations and an overview of preliminary study results as well as the General Electric EEE clearance control approach is presented. Finally, potential fuel savings with active control of rotor clearances for a typical EEE mission are predicted. M.E.P.

A80-50191 * # **An acoustic sensitivity study of general aviation propellers.** K. D. Korkan, G. M. Gregorek (Ohio State University, Columbus, Ohio), and I. Keiter (Cessna Aircraft Co., Vandalia, Ohio). *American Institute of Aeronautics and Astronautics, Aircraft Systems Meeting, Anaheim, Calif., Aug. 4-6, 1980, Paper 80-1871.* 32 p. 22 refs. Contract No. NAS3-21719.

This paper describes the results of a study in which a systematic approach has been taken in studying the effect of selected propeller parameters on the character and magnitude of propeller noise. Four general aviation aircraft were chosen, i.e., a Cessna 172, Cessna 210, Cessna 441, and a 19 passenger commuter concept, to provide a range in flight velocity, engine horsepower, and gross weight. The propeller parameters selected for examination consisted of number of blades, rpm reduction, thickness/chord reduction, activity factor reduction, proplets, airfoil improvement, sweep, position of maximum blade loading, and diameter reduction. (Author)

08 AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities, piloting, flight controls, and autopilots

N80-29369*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
SINGLE-STAGE ELECTROHYDRAULIC SERVOSYSTEM FOR ACTUATING ON AIRFLOW VALVE WITH FREQUENCIES TO 500 HERTZ
John A. Webb, Jr., Oral Mehmed, and Carl F. Lorenzo Aug 1980 35 p refs
(NASA TP-1678, E-252) Avail: NTIS HC A03/MF A01 CSCL 01C

An airflow valve and its electrohydraulic actuation servosystem are described. The servosystem uses a high-power, single-stage servovalve to obtain a dynamic response beyond that of systems designed with conventional two-stage servovalves. The electrohydraulic servosystem is analyzed and the limitations imposed on system performance by such nonlinearities as signal saturations and power limitations are discussed. Descriptions of the mechanical design concepts and developmental considerations are included. Dynamic data, in the form of sweep-frequency test results, are presented and comparison with analytical results obtained with an analog computer model is made. R.K.G.

09 RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

For related information see also *14 Ground Support Systems and Facilities (Space).*

N80-32404*# Southampton Univ. (England). Dept. of Aeronautics and Astronautics.
SELECTED DATA FROM A TRANSONIC FLEXIBLE WALLED TEST SECTION Semiannual Progress Report
S. W. D. Wolf Sep. 1980 108 p refs
(Grant NsG-7172)
(NASA-CR-159360) Avail: NTIS HC A06/MF A01 CSCL 14B

Twenty four test runs of the Transonic Self-Streamlining Wind Tunnel were performed with the flexible walls 'streamlined' around a two dimensional section of four inch chord, over the Mach number range 0.3 to 0.89. Relevant wall and model data for the streamlined cases are presented. L.F.M.

12 ASTRONAUTICS (GENERAL)

For extraterrestrial exploration see *91 Lunar and Planetary Exploration*

A80-20961 * # Cost-effective technology advancement directions for electric propulsion transportation systems in earth-orbital missions. J. D. Regetz, Jr. (NASA, Lewis Research Center, Cleveland, Ohio) and C. H. Terwilliger, Jr. (Boeing Aerospace Co., Seattle, Wash.). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2043.* 19 p.

This paper presents the results of a study to determine the directions that electric propulsion technology should take to meet the primary propulsion requirements for earth-orbital missions of the next three decades in the most cost-effective manner. Discussed are the mission set requirements, state-of-the-art electric propulsion technology and the baseline system characterized by it, adequacy of the baseline system to meet the mission set requirements, cost-optimum electric propulsion system characteristics for the mission set, and sensitivities of mission costs and design points to system-level electric propulsion parameters. It is found that the efficiency-specific impulse characteristic generally has a more significant impact on overall costs than specific masses or costs of propulsion and power systems. (Author)

A80-35504 * # LeRC reduced gravity fluid management technology program. J. C. Aydelott and E. P. Symons (NASA, Lewis Research Center, Cleveland, Ohio). *Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee, Propulsion Meeting, Monterey, Calif., Mar. 11-13, 1980, Paper.* 18 p. 38 refs.

The program reviewed in the present paper has provided information of the reduced-gravity behavior of fluids, thermal control of cryogenic tankage, and fluid management system design. The studies are currently shifting from the utilization of in-house experimental facilities to the development of Spacelab experiments. The cryogenic fluid management experiment, currently undergoing detailed design, is expected to provide an orbital evaluation of a subcritical liquid hydrogen storage and supply system, as part of the Shuttle/Spacelab program. Efforts are continuing to develop computer techniques for simulating reduced-gravity fluid dynamic processes. V.P.

N80-31423*# General Dynamics/Convair, San Diego, Calif.
CONCEPTUAL DESIGN OF AN ORBITAL PROPELLANT TRANSFER EXPERIMENT. VOLUME 2: STUDY RESULTS
G. L. Drake, C. E. Bassett, F. Merino, L. E. Siden, R. E. Bradley, E. J. Carr, and R. E. Parker Aug. 1980 196 p refs
(Contract NAS3-21935)
(NASA-CR-165150; GDC-ASP-80-013-Vol-2) Avail: NTIS HC A09/MF A01 CSCL 22A

The OTV configurations, operations and requirements planned for the period from the 1980's to the 1990's were reviewed and a propellant transfer experiment was designed that would support the needs of these advanced OTV operational concepts. An overall integrated propellant management technology plan for all NASA centers was developed. The preliminary cost estimate (for planning purposes only) is $56.7 M, of which approximately $31.8 M is for shuttle user costs. R.K.G.

N80-32412*# General Dynamics/Convair, San Diego, Calif.
COMPARATIVE THERMAL ANALYSIS OF ALTERNATE CRYOGENIC FLUID MANAGEMENT EXPERIMENT (CFME) CONFIGURATIONS
F. Merino and R. F. ONeill Jul. 1980 66 p refs
(Contract NAS3-21935)
(NASA-CR-165151; GDC-CRAD-80-014) Avail: NTIS HC A04/MF A01 CSCL 22A

The Cryogenic Fluid Management Experiment (CFME) was analyzed to assess the feasibility and advisability of deleting the vapor cooled shield (VCS) from the baseline CFME insulation and pressure control system Two alternate concepts of CFME insulation and pressure control, neither of which incorporated the VCS, were investigated The first concept employed a thermodynamic vent system (TVS) to throttle the flow through an internal wall mounted heat exchanger (HX) within the pressure vessel to decrease boiloff and pressure rise rate, while the second concept utilized a TVS without an internal heat exchanger Only the first concept was viable Its performance was assessed for a seven day mission and found to be satisfactory It was also concluded that VCS development costs would be greater than for an internal HX installation Based upon the above comparisons, the HX was recommended as a replacement for the VCS A R H

14 GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)

Includes launch complexes, research and production facilities, ground support equipment, mobile transporters, and simulators.

For related information see also *09 Research Support Facilities (Air)*.

A80-13308 * # **An electric propulsion long term test facility.** G. Trump, E. James (Xerox Electro-Optical Systems, Pasadena, Calif.), R. Vetrone, and R. Bechtel (NASA, Lewis Research Center, Cleveland, Ohio). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2080.* 8 p. Contract No. NAS3-20399.

An existing test facility was modified to provide for extended testing of multiple electric propulsion thruster subsystems. A program to document thruster subsystem characteristics as a function of time is currently in progress. The facility is capable of simultaneously operating three 2.7-kW, 30-cm mercury ion thrusters and their power processing units. Each thruster is installed via a separate air lock so that it can be extended into the 7m x 10m main chamber without violating vacuum integrity. The thrusters exhaust into a 3m x 5m frozen mercury target. An array of cryopanels collect sputtered target material. Power processor units are tested in an adjacent 1.5m x 2m vacuum chamber or accompanying forced convection enclosure. The thruster subsystems and the test facility are designed for automatic unattended operation with thruster operation computer controlled. Test data are recorded by a central data collection system scanning 200 channels of data a second every two minutes. Results of the Systems Demonstration Test, a short shakedown test of 500 hours, and facility performance during the first year of testing are presented. (Author)

N80-27403*# General Dynamics/Convair, San Diego, Calif.
CONCEPTUAL DESIGN OF TWO-PHASE FLUID MECHANICS AND HEAT TRANSFER FACILITY FOR SPACELAB
B. F. North and M. E. Hill Jun. 1980 190 p refs
(Contract NAS3-21750)
(NASA-CR-159810; GDC-CRAD-80-002) Avail: NTIS HC A09/MF A01 CSCL 14B

Five specific experiments were analyzed to provide definition of experiments designed to evaluate two phase fluid behavior in low gravity. The conceptual design represents a fluid mechanics and heat transfer facility for a double rack in Spacelab. The five experiments are two phase flow patterns and pressure drop, flow boiling, liquid reorientation, and interface bubble dynamics. Hardware was sized, instrumentation and data recording requirements defined, and the five experiments were installed as an integrated experimental package. Applicable available hardware was selected in the experiment design and total experiment program costs were defined. Author

15 LAUNCH VEHICLES AND SPACE VEHICLES

Includes boosters, manned orbital laboratories, reusable vehicles and space stations

N80-25367*# General Electric Co., Philadelphia, Pa. Space Div.
STUDY OF ADVANCED COMMUNICATIONS SATELLITE SYSTEMS BASED ON SS-FDMA
John Kiesling May 1980 359 p
(Contract NAS3-21745)
(NASA-CR-159778; DOC-80SDS4217) Avail: NTIS HC A16/MF A01 CSCL 22B

A satellite communication system based on the use of a multiple, contiguous beam satellite antenna and frequency division multiple access (FDMA) is studied. Emphasis is on the evaluation of the feasibility of SS (satellite switching) FDMA technology, particularly the multiple, contiguous beam antenna, the onboard switch and channelization, and on methods to overcome the effects of severe Ka band fading caused by precipitation. This technology is evaluated and plans for technology development and evaluation are given. The application of SS-FDMA to domestic satellite communications is also evaluated. Due to the potentially low cost Earth stations, SS-FDMA is particularly attractive for thin route applications up to several hundred kilobits per second, and offers the potential for competing with terrestrial facilities at low data rates and over short routes. The onboard switch also provides added route flexibility for heavy route systems. The key beneficial SS-FDMA strategy is to simplify and thus reduce the cost of the direct access Earth station at the expense of increased satellite complexity. E.D.K.

A80-35329 * # Concepts for 20/30 GHz satcom systems for direct-to-user applications. R. Jorasch, R. Davies, and M. Baker (Ford Aerospace and Communications Corp., Palo Alto, Calif.). In: Communications Satellite Systems Conference, 8th, Orlando, Fla., April 20-24, 1980, Technical Papers. Conference sponsored by the American Institute of Aeronautics and Astronautics. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, 8 p. Contract No. NAS3-21362. (AIAA 80-0582)

A baseline technique is described for implementing a direct-to-user (DTU) satcom communications system at 20/30 GHz transmission frequency. The purpose of this application is to utilize the high capacity frequency spectrum at K(A) band for communications among thousands of small terminals located at or close to a customer's facility. The baseline DTU system utilizes a TDMA method of communications with QPSK modulation. Twenty-five coverage beams from a geosynchronous orbit spacecraft provide full coverage of CONUS. Low cost terminals are limited to less than 4.5 meters diameter. The impact of rain attenuation on communications availability is examined. Other techniques including satellite switched antenna beams are outlined and critical K(A)-band technology developments are identified. (Author)

16 SPACE TRANSPORTATION

Includes passenger and cargo space transportation e g , shuttle operations, and rescue techniques.
For related information see also *03 Air Transportation and Safety* and *85 Urban Technology and Transportation.*

N80-20304*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
LeRC REDUCED GRAVITY FLUID MANAGEMENT TECHNOLOGY PROGRAM
John C. Aydelott and E Patrick Symons [1980] 19 p refs
Prepared for the 1980 JANNAF Propulsion Meeting, Monterey, Calif., 11-13 Mar. 1980
(NASA-TM-81450; E-371) Avail: NTIS HC A02/MF A01 CSCL 22A

A survey of the reduced gravity fluid management technology program is presented. Information on reduced gravity fluid behavior, techniques for thermal control of cryogenic tankage, and design for fluid management systems are discussed. The development of Spacelab experiments, propellant management systems for orbit transfer vehicles, and computer techniques for simulating reduced gravity fluid dynamic processes is reported.
A.W.H.

A80-10032 * # Communications technology satellite - United States experiments and disaster communications applications. P. L. Donoughe, H. R. Hunczak, and G. S. Gurski (NASA, Lewis Research Center, Cleveland, Ohio). *United Nations, Regional Seminar on the Use of Satellite Technology for Disaster Applications, São José dos Campos, São Paulo, Brazil, Oct. 2-13, 1978, Paper.* 43 p. 22 refs.

The experimental Communications Technology Satellite (CTS), also called Hermes, uses a high-power transmitter and 12- and 14-GHz frequencies for wideband (two- and one-way television) and narrowband (voice, data) communications. In the joint program, both Canada and the United States have conducted a variety of communications experiments. This report concentrates on U.S. CTS experiments and miniexperiments that use ground antennas from 0.6 to 5 meters in diameter. The U.S. CTS experiments program is synopsized in this report. The use of CTS for simulated and actual disasters is summarized. (Author)

17 SPACECRAFT COMMUNICATIONS, COMMAND AND TRACKING

Includes telemetry; space communications networks; astronavigation; and radio blackout.

For related information see also *04 Aircraft Communications and Navigation* and *32 Communications.*

N80-21412*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A DIGITALLY IMPLEMENTED COMMUNICATIONS EXPERIMENT UTILIZING THE COMMUNICATIONS TECHNOLOGY SATELLITE, HERMES

H D Jackson and J. Fiala Mar. 1980 19 p refs

(NASA-TM-81452, E-379) Avail NTIS HC A02/MF A01 CSCL 17B

Developments which will reduce the costs associated with the distribution of satellite services are considered with emphasis on digital communication link implementation. A digitally implemented communications experiment (DICE) which demonstrates the flexibility and efficiency of digital transmission of television video and audio, telephone voice, and high-bit-rate data is described. The utilization of the DICE system in a full duplex teleconferencing mode is addressed. Demonstration teleconferencing results obtained during the conduct of two sessions of the 7th AIAA Communication Satellite Systems Conference are discussed. Finally, the results of link characterization tests conducted to determine (1) relationships between the Hermes channel 1 EIRP and DICE model performance and (2) channel spacing criteria for acceptable multichannel operation, are presented. J.M.S.

18 SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Includes spacecraft thermal and environmental control; and attitude control.

For life support systems see *54 Man/System Technology and Life Support*. For related information see also *05 Aircraft Design, Testing and Performance* and *39 Structural Mechanics.*

N80-15200*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CONFIGURATION EFFECTS ON SATELLITE CHARGING RESPONSE

C. K. Purvis 1980 20 p refs Presented at 18th Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980; sponsored by AIAA

(NASA-TM-81397; E-307) Avail: NTIS HC A02/MF A01 CSCL 22B

The response of various spacecraft configurations to a charging environment in sunlight was studied using the NASA Charging Analyzer Program code. The configuration features geometry, type of stabilization, and overall size. Results indicate that sunlight charging response is dominated by differential charging effects. Shaded insulation charges negatively result in the formation of

N80-16093*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF SECONDARY YIELD PARAMETER VARIATION ON PREDICTED EQUILIBRIUM POTENTIAL OF AN OBJECT IN A CHARGING ENVIRONMENT

Carolyn K. Purvis 1979 21 p refs Presented at the Ann. Conf. on Nucl. and Space Radiation Effects, Santa Cruz, Calif., 16-20 Jul. 1979; sponsored by IEEE

(NASA-TM-79299; E-117) Avail: NTIS HC A02/MF A01 CSCL 22B

The sensitivity of predicted equilibrium potential to changes in secondary electron yield parameters was investigated using MATCHG, a simple charging code which incorporates the NASCAP material property formulations. The equilibrium potential was found to be a sensitive function of one of the two parameters specifying secondary electron yield due to proton impact and of essentially all the parameters specifying yield due to electron impact. The information on the electron generated secondary yield parameters was discovered to be obtainable from monoenergetic beam charging data if charging rates as well as equilibrium potentials are accurately recorded. A.W.H.

N80-16094*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTED VOLTAGE DISTRIBUTIONS AROUND SOLAR ELECTRIC PROPULSION SPACECRAFT

N. John Stevens 1979 20 p refs Presented at 14th Intern. Conf. on Elec. Propulsion, Princeton, N.J., 30 Oct. - 1 Nov. 1979; sponsored by AIAA and DGLR

(NASA-TM-79286; E-225) Avail: NTIS HC A02/MF A01 CSCL 22B

The NASA Charging Analyzer Program is used to conduct preliminary computations of the voltage distributions around such large spacecraft in geomagnetic substorm environments at geosynchronous altitudes. Both a standard operating voltage (+ or - 150 volts on solar arrays) and direct-drive (+1200 volts on arrays) configurations are considered. Thruster-off simulations are computed for both operating voltage configurations while the effect of simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster operations appear to alleviate surface charging. M.M.M.

N80-18095*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASCAP MODELLING COMPUTATIONS ON LARGE OPTICS SPACECRAFT IN GEOSYNCHRONOUS SUBSTORM ENVIRONMENTS

N. John Stevens and Carolyn K. Purvis 1980 20 p refs Presented at Soc. of Photo-Optical Instrumentation Engineers, Los Angeles Technical Symp., North Hollywood, Calif., 4-7 Feb. 1980

(NASA-TM-81395; E-305) Avail: NTIS HC A02/MF A01 CSCL 22B

The NASA Charging Analyzer Program (NASCAP) is used to evaluate qualitatively the possibility of such enhanced spacecraft contamination on a conceptual version of a large satellite. The evaluation is made by computing surface voltages on the satellite due to encounters with substorm environments and then computing charged particle trajectories in the electric fields around the satellite. Particular attention is paid to the possibility of contaminants reaching a mirror surface inside a dielectric tube because this mirror represents a shielded optical surface in the satellite model used. Deposition of low energy charged particles from other parts of the spacecraft onto the mirror was found to be possible in the assumed moderate substorm environment condition. In the assumed severe substorm environment condition, however, voltage build up on the inside and edges of the dielectric tube in which the mirror is located prevents contaminants from reaching the mirror surface. J.M.S.

N80-32428*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MODELLING OF ENVIRONMENTALLY INDUCED DISCHARGES IN GEOSYNCHRONOUS SATELLITES

N. John Stevens 1980 9 p refs Presented at the Ann. Conf. on Nucl. and Space Radiation Effects, Ithaca, N.Y., 15-18 Jul. 1980; sponsored by IEEE

(NASA-TM-81598; E-581) Avail: NTIS HC A02/MF A01 CSCL 22B

The NASCAP computer code was used to compute the charging and discharging characteristics of a typical communications satellite in geosynchronous orbit. For the case of a severe substorm satellite surface differential charging in sunlight was found to be substantially less than that required to produce discharges in ground simulation studies. A discharge process was postulated involving discharges triggered at edges (or imperfection) followed by discharges to space. The characteristics of such discharges was parametrically varied to evaluate the possible effects on the satellite. Results indicated that discharge characteristics inferred from satellite monitors could be caused by predicted space discharges, that single cell discharges to space can reduce surface potentially over entire satellite, and that low density electron trajectory computations indicate that discharge generated electrons do not return to the satellite by long trajectories. Current transients predicted do not agree with available ground simulation results indicating that additional work must be done both analytically and experimentally to understand and fully explain these discrepancies. R.C.T.

A80-19773 * **Photoelectron charge density and transport near differentially charged spacecraft.** M. J. Mandell, I. Katz, G. W. Schnuelle (Systems, Science and Software, La Jolla, Calif.), and J. C. Roche (NASA, Lewis Research Center, Cleveland, Ohio). *(IEEE, U.S. Defense Nuclear Agency, and Jet Propulsion Laboratory, Annual Conference on Nuclear and Space Radiation Effects, 16th, Santa Cruz, Calif., July 17-20, 1979.) IEEE Transactions on Nuclear Science*, vol. NS-26, Dec. 1979, p. 5107-5111. 5 refs. USAF-supported research; Contract No. NAS3-21762.

The effects of photoelectron space charge and current density on differentially charged spacecraft are studied. The steady-state potentials of a sunlit cylinder are calculated using a two-dimensional computer code with a fully self-consistent treatment of space charge and an effective surface conductivity treatment of photoelectron currents. It is found that under conditions of strong differential charging the results do not differ greatly from NASCAP results, which neglect photosheath space charge and currents. (Author)

A80-19774 * **NASCAP modelling of environmental-charging-induced discharges in satellites.** N. J. Stevens and J. C. Roche (NASA, Lewis Research Center, Cleveland, Ohio). *(IEEE, U.S. Defense Nuclear Agency, and Jet Propulsion Laboratory, Annual Conference on Nuclear and Space Radiation Effects, 16th, Santa Cruz, Calif., July 17-20, 1979.) IEEE Transactions on Nuclear Science*, vol. NS-26, Dec. 1979, p. 5112-5120. 22 refs.

A study of the charging and discharging characteristics of a typical geosynchronous satellite experiencing time-varying geomagnetic substorms, in sunlight, is conducted. The NASA Charging Analyzer Program (NASCAP) is used. An electric field criteria of 1.5 x 10 to the 5th volts/cm to initiate discharges and transfer of 67% of the stored charge is used in this study, based on ground test results. The substorm characteristics are arbitrarily chosen to evaluate effects of electron temperature and particle density (which is equivalent to current density). It has been found that while there is a minimum electron temperature for discharges to occur, the rate of discharges is dependent on particle density and duration times of the encounter. Hence, it is important to define the temporal variations in the substorm environments. (Author)

A80-29750 * # **Computed voltage distribution around Solar Electric Propulsion spacecraft.** N. J. Stevens (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesselschaft für Luft- und Raumfahrt, International Conference on Electric Propulsion, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2104.* 18 p. 31 refs.

The paper uses the NASCAP computer code to compute voltage distributions around a Solar Electric Propulsion (SEP) spacecraft as it encounters an idealized geomagnetic substorm environment. Consideration is given to both a standard operating voltage and direct-drive voltage configuration. The computations are presented without thruster operations as well as with a simplified, simulated thruster-on representation for direct-drive configuration only. Finally, it is stressed that the computations seeking possible areas of concern in the spacecraft design are exploratory. M.E.P.

A80-29751 * # **Initial comparison of SSPM ground test results and flight data to NASCAP simulations.** N. J. Stevens, J. V. Staskus, J. C. Roche (NASA, Lewis Research Center, Cleveland, Ohio), and P. F. Mizera (Aerospace Corp., Space Sciences Laboratory, Los Angeles, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0336.* 16 p. 23 refs.

The satellite surface potential monitor (SSPM) has been developed for the P78-2 SCATHA (Spacecraft Charging At The High Altitudes) satellite to determine the response of selected spacecraft materials to charged-particle environmental fluxes. Since the monitor infers total surface voltages from a single point on the interior side of insulators, a ground simulation program was undertaken to develop analytical techniques to model the monitors and to obtain an experimental calibration of the relationship between the flight measurement techniques and actual measurements. The experimental testing was conducted using monoenergetic electron beams irradiating samples in the dark. An analytical computer model was developed in the NASCAP (NASA Charging Analyzer Program) code. The analytical model material properties for Kapton that controlled backscatter and secondary yield were adjusted to obtain a single set of values that produced reasonable fits for both voltages and currents. The analytical techniques developed in the ground technology investigation have been applied to space flight conditions. Predictions were compared with limited flight data. The agreement is very good indicating that the technique, and NASCAP, can be used to predict spacecraft material charging behavior. Details of the testing, the analytical modelling technique and flight data comparisons are presented. (Author)

A80-32829 * # **NASCAP modelling computations on large optics spacecraft in geosynchronous substorm environments.** N. J. Stevens and C. K. Purvis (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Photo-Optical Instrumentation Engineers, Los Angeles Technical Symposium, North Hollywood, Calif., Feb. 4-7, 1980, Paper.* 18 p. 20 refs.

Satellites in geosynchronous orbits have been found to be charged to significant negative voltages during encounters with geomagnetic substorms. When satellite surfaces are charged, there is a probability of enhanced contamination from charged particles attracted back to the satellite by electrostatic forces. This could be particularly disturbing to large satellites using sensitive optical systems. In this study the NASA Charging Analyzer Program (NASCAP) is used to evaluate qualitatively the possibility of such enhanced contamination on a conceptual version of a large satellite. The evaluation is made by computing surface voltages on the satellite due to encounters with substorm environments and then computing charged-particle trajectories in the electric fields around the satellite. Particular attention is paid to the possibility of contaminants reaching a mirror surface inside a dielectric tube because this mirror represents a shielded optical surface in the satellite model used. Deposition of low energy charged particles from other parts of the spacecraft onto the mirror was found to be possible in the assumed moderate substorm environment condition. In the assumed severe substorm environment condition, however, voltage build up on the inside and edges of the dielectric tube in which the mirror is located prevents contaminants from reaching the mirror surface. (Author)

A80-38909 * # **A liquid hydrogen experiment as a Shuttle payload.** R. N. Eberhardt, D. A. Fester (Martin Marietta Aerospace, Denver, Colo.), and J. C. Aydelott (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1096.* 17 p. 18 refs. Contract No. NAS3-21591.

The paper describes the cryogenic fluid management experiment (CFME) as a Shuttle payload. The experiment includes a liquid hydrogen tank containing a fine-mesh screen acquisition device, and a thermal control system consisting of a thermodynamic vent system to intercept heat leak to the hydrogen tank and control tank pressure. Engineering data obtained will be used to establish design criteria for subcritical cryogenic storage and supply tankage. V.T.

A80-41897 * # **Orbital transfer of large space structures with nuclear electric rockets.** T. H. Silva (Aerospace Corp., El Segundo, Calif.) and D. C. Byers (NASA, Lewis Research Center, Electric Thruster Section, Cleveland, Ohio). *American Astronautical Society, Goddard Memorial Symposium, 18th, Washington, D.C., Mar. 27, 28, 1980, Paper 80-083.* 13 p. 17 refs.

This paper discusses the potential application of electric propulsion for orbit transfer of a large spacecraft structure from low earth orbit to geosynchronous altitude in a deployed configuration. The electric power was provided by the spacecraft nuclear reactor space power system on a shared basis during transfer operations. Factors considered with respect to system effectiveness included nuclear power source sizing, electric propulsion thruster concept, spacecraft deployment constraints, and orbital operations and safety. It is shown that the favorable total impulse capability inherent in electric propulsion provides a potential economic advantage over chemical propulsion orbit transfer vehicles by reducing the number of Space Shuttle flights in ground-to-orbit transportation requirements. (Author)

A80-44238 * # **Effects of secondary yield parameter variation on predicted equilibrium potential of an object in a charging environment.** C. K. Purvis (NASA, Lewis Research Center, Cleveland, Ohio). *Institute of Electrical and Electronics Engineers, Annual Conference on Nuclear and Space Radiation Effects, Santa Cruz, Calif., July 16-20, 1979, Paper.* 19 p.

A study is presented in which the sensitivity of predicted equilibrium potential to changes in secondary electron yield parameters is investigated using MATCHG, a simple charging code which incorporates the NASCAP material property formulations. It is found that equilibrium potential is a sensitive function of one of the two parameters specifying secondary electron yield due to proton impact and of essentially all the parameters specifying yield due to electron impact. In addition, it is found that information on the electron generated secondary yield parameters can be obtained from monoenergetic beam charging data if charging rates as well as equilibrium potentials are accurately recorded. M.E.P.

A80-45609 * **First results of material charging in the space environment.** P. F. Mizera, H. C. Koons, E. R. Schnauss, D. R. Croley, Jr., H. K. A. Kan, M. S. Leung (Aerospace Corp., El Segundo, Calif.), N. J. Stevens, F. Berkopec, J. Staskus (NASA, Lewis Research Center, Cleveland, Ohio), and W. L. Lehn (USAF, Materials Laboratory, Wright-Patterson AFB, Ohio). *Applied Physics Letters*, vol. 37, Aug. 1, 1980, p. 276-279. 5 refs. Contract No. F04701-79-C-0080.

A satellite experiment, designed to measure potential charging of typical thermal-control materials at near-geosynchronous altitude, was flown as part of the Spacecraft Charging at High Altitudes program. Direct observations of charging of typical satellite materials in a natural charging event (greater than or equal to 5 keV) are presented. The results show some features which differ significantly from previous laboratory simulations of the environment. (Author)

A80-46890 * // **Active control of spacecraft charging.** C. K. Purvis (NASA, Lewis Research Center, Cleveland, Ohio) and R. O. Bartlett (NASA, Goddard Space Flight Center, Greenbelt, Md.). In: Space systems and their interactions with earth's space environment. (A80-46879 20-18) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 299-317. 23 refs.

The concept of active control of spacecraft charging by charged particle emission is described. Active potential control experiments using the ATS-5 and ATS-6 geostationary spacecraft are discussed, and results of these experiments are presented. Previously reported results are summarized, and a guide to reports on these data are provided. Experimental evidence presented indicates that emission of electrons only is not effective in maintaining spacecraft potential near plasma potential for spacecraft with electrically insulating surfaces. Emission of a low energy plasma, however, is effective for this purpose. (Author)

A80-46891 * // **A three-dimensional spacecraft-charging computer code.** A. G. Rubin (USAF, Geophysics Laboratory, Bedford, Mass.), I. Katz, M. Mandell, G. Schnuelle, P. Steen, D. Parks, J. Cassidy (Systems Science and Software, Inc., La Jolla, Calif.), and J. Roche (NASA, Lewis Research Center, Cleveland, Ohio). In: Space systems and their interactions with earth's space environment. (A80-46879 20-18) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 318-336. 9 refs.

A computer code is described which simulates the interaction of the space environment with a satellite at geosynchronous altitude. Employing finite elements, a three-dimensional satellite model has been constructed with more than 1000 surface cells and 15 different surface materials. Free space around the satellite is modeled by nesting grids within grids. Applications of this NASA Spacecraft Charging Analyzer Program (NASCAP) code to the study of a satellite photosheath and the differential charging of the SCATHA (satellite charging at high altitudes) satellite in eclipse and in sunlight are discussed. In order to understand detector response when the satellite is charged, the code is used to trace the trajectories of particles reaching the SCATHA detectors. Particle trajectories from positive and negative emitters on SCATHA also are traced to determine the location of returning particles, to estimate the escaping flux, and to simulate active control of satellite potentials. (Author)

A80-46897 * // **Space environmental interactions with biased spacecraft surfaces.** N. J. Stevens (NASA, Lewis Research Center, Spacecraft Environment Section, Cleveland, Ohio). In: Space systems and their interactions with earth's space environment. (A80-46879 20-18) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 455-476. 31 refs.

Large, high-voltage space power systems are being proposed for future space missions. These systems must operate in the charged-particle environment of space, and interactions between this environment and the high-voltage surfaces are possible. Ground simulation testing has indicated that dielectric surfaces that usually surround biased conductors can influence these interactions. For positive voltages greater than 100 V, it has been found that the dielectrics contribute to discharges. Using these experimental results a large, high-voltage power system operating in geosynchronous orbit was analyzed with the NASCAP code. Results of this analysis indicated that very strong electric fields exist in these power systems. A technology investigation is required to understand the interactions and develop techniques to alleviate any impact on power system performance. (Author)

A80-13301 * // **Evaluation of particle transport for the P80-1 spacecraft.** J. M. Sellen, Jr. and G. K. Komatsu (TRW Defense and Space Systems Group, Redondo Beach, Calif.). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2047.* 7 p. Contract No. NAS3-21047.

Charged and neutral particle transport from an 8-cm mercury ion thruster to the surfaces of the P80-1 spacecraft, the Teal Ruby sensor and the ECOM-501 sensor was examined. Evaluation of particle transport modes utilized both laboratory measurements and analysis. Line-of-sight particle transport considered deposition of Group II (high energy-high angle mercury charge exchange) ions and neutral mercury on solar array surfaces. Nonline-of-sight transport modes studied were recirculation/reinterception of mercury ions in magnetic fields and refraction of low energy mercury charge exchange (Group IV) ions by local electric fields. (Author)

A80-18249 * // **Plasma collection by high voltage spacecraft at low earth orbit.** I. Katz, M. J. Mandell, G. W. Schnuelle, D. E. Parks, and P. G. Steen (Systems, Science and Software, La Jolla, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0042.* 7 p. 11 refs. USAF-supported research; Contract No. NAS3-21762.

A computer model of the three-dimensional sheath formation and plasma current collection by high voltage spacecraft has been developed. By using new space charge density and plasma collection algorithms, it is practical to perform calculations for large, complex spacecraft. The model uses NASCAP compatible objects and geometries. Results indicate that ion focusing observed in the laboratory during high voltage collection experiments is probably due to voltage gradients on the collecting surfaces. (Author)

20 SPACECRAFT PROPULSION AND POWER

Includes main propulsion systems and components e.g., rocket engines; and spacecraft auxiliary power sources.
For related information see also *07 Aircraft Propulsion, 28 Propellants and Fuels,* and *44 Energy Production and Conversion.*

N80-13159*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
Hg ION THRUSTER COMPONENT TESTING
M. A. Mantenieks 1979 15 p refs Presented at 14th Intern. Conf. on Elec. Propulsion, Princeton, N. J., 30 Oct - 1 Nov. 1979; sponsored by AIAA and DGLR
(NASA-TM-79287; E-230) Avail: NTIS HC A02/MF A01 CSCL 21C

Electron bombardment thrusters, under development to provide both auxiliary and primary propulsion functions for a large variety of space missions are tested. Thruster design verification which requires life tests of durations of the order of the time anticipated in space applications, are discussed. The life time and reliability of an electron bombardment thruster is dependent upon the performance of several critical components including cathodes, vaporizers, and isolators. The performances of the cathode, vaporizer, and propellant isolaters during fatigue analyses are examined. A.W.H.

N80-13163*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN AND EVALUATION OF HIGH PERFORMANCE ROCKET ENGINE INJECTORS FOR USE WITH HYDROCARBON FUELS
A. J. Pavli 1979 20 p refs Presented at the 16th JANNAF Combustion Conf., Monterey, Calif., 10-14 Sep. 1979
(NASA-TM-79319; E-275) Avail: NTIS HC A02/MF A01 CSCL

The feasibility of using a heavy hydrocarbon fuel as a rocket propellant is examined. A method of predicting performance of a heavy hydrocarbon in terms of vaporization effectiveness is described and compared to other fuels and to experimental test results. Experiments were done at a chamber pressure of 4137 KN/sq M (600 psia) with RP-1, JP-10, and liquefied natural gas as fuels, and liquid oxygen as the oxidizer. Combustion length effects were explored over a range of 21.6 cm (8 1/2 in) to 55.9 cm (22 in). Four injector types were tested, each over a range of mixture ratios. Further configuration modifications were obtained by reaming each injector several times to provide test data over a range of injector pressure drop. J.M.S.

N80-14188* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUPERCHARGED TOPPING ROCKET PROPELLANT FEED SYSTEM Patent
Warner L. Stewart, Ambrose Ginsburg, and Melvin J. Hartmann, inventors (to NASA) Issued 23 Oct. 1979 6 p Filed 21 Apr. 1966
(NASA-Case-XLE-02062-1; US-Patent-4,171,615; US-Patent-Appl-SN-545793; US-Patent-Class-60-203; US-Patent-Class-60-259) Avail: US Patent and Trademark Office CSCL 21H

A rocket propellant feed system utilizing a bleed turbopump to supercharge a topping turbopump is presented. The bleed turbopump is of a low pressure type to meet the cavitation requirements imposed by the propellant storage tanks. The topping turbopump is of a high pressure type and develops 60 to 70 percent of the pressure rise in the propellant.
Official Gazette of the U.S. Patent and Trademark Office

N80-15204*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
ANALYSIS OF GaAs AND Si SOLAR CELL ARRAYS FOR EARTH ORBITAL AND ORBIT TRANSFER MISSIONS
Kent D Jeffries 1980 9 p refs Presented at 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan 1980; sponsored by IEEE
(NASA-TM-81383, E-291) Avail NTIS HC A02/MF A01 CSCL 21C

Silicon and gallium arsenide arrays were studied and compared for low earth orbit (LE), geosynchronous orbit (GEO), and LEO to GEO electric propulsion orbit transfer missions. The sensitivities of total cost to parameters such as mission duration, array cost, cover glass thickness, and concentration ratio were determined along with cost tradeoffs between silicon and gallium arsenide arrays for selected mission classes. Results indicate that development of the technology for low cost, light weight concentrators should be increased and that cost reduction efforts for gallium arsenide cells be pursued R.C.T.

N80-16097*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
UPPER STAGES UTILIZING ELECTRIC PROPULSION
David C. Byers 1980 21 p refs Presented at the JANNAF Propulsion Meeting, Monterey, Calif., 11-13 Mar. 1980
(NASA-TM-81412; E-330) Avail: NTIS HC A02/MF A01 CSCL 21C

The payload characteristics of geocentric missions which utilize electron bombardment ion thruster systems are discussed. A baseline LEO to GEO orbit transfer mission was selected to describe the payload capabilities. The impacts on payloads of both mission parameters and electric propulsion technology options were evaluated. The characteristics of the electric propulsion thrust system and the power requirements were specified in order to predict payload mass. This was completed by utilizing a previously developed methodology which provides a detailed thrust system description after the final mass on orbit, the thrusting time, and the specific impulse are specified. The impact on payloads of total mass in LEO, thrusting time, propellant type, specific impulse, and power source characteristics was evaluated. A.W.H.

N80-17138*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL INVESTIGATION OF TWO HYDROGEN OXYGEN ROCKET ENGINE SYSTEMS FOR LOW-THRUST APPLICATION
Dean D. Scheer 1980 17 p refs Presented at JANNAF Propulsion Meeting, Monterey, Calif., 11-13 Mar. 1980
(NASA-TM-81420; E-343) Avail: NTIS HC A02/MF A01 CSCL 21H

Two hydrogen oxygen rocket engine system concepts were analyzed parametrically over a thrust range from 100 to 1000 pounds and a chamber pressure range from 175 to 1000 psia. Both concepts were regeneratively cooled with hydrogen and were pump fed by electric motor driven positive displacement pumps. Electric power was provided by either a turboalternator (turboalternator concept) or some means external to the engine system (auxiliary power concept). The turboalternator concept is discussed. The computer program used to conduct the analyses along with the design characteristics of the major engine system components is described. The feasible design range of the systems over the parametric range of thrust is discussed in terms of allowable chamber pressure. Engine system estimated performance, mass, and dimensional envelope parametric data within the feasible design range are presented. A.W.H.

N80-18098*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ECONOMIC ANALYSIS OF THE DESIGN AND FABRICATION OF A SPACE QUALIFIED POWER SYSTEM
Gregory Ruselowski Jan. 1980 25 p refs
(NASA-TM-81418; E-339) Avail: NTIS HC A02/MF A01 CSCL 10B

An economic analysis was performed to determine the cost of the design and fabrication of a low Earth orbit, 2 kW photovoltaic/battery, space qualified power system. A commercially available computer program called PRICE (programmed review of information for costing and evaluation) was used to conduct the analysis. The sensitivity of the various cost factors to the assumptions used is discussed. Total cost of the power system was found to be $2.46 million with the solar array accounting for 70.5%. Using the assumption that the prototype becomes the flight system, 77.3% of the total cost is associated with manufacturing. Results will be used to establish whether the cost of space qualified hardware can be reduced by the incorporation of commercial design, fabrication, and quality assurance methods. J.M.S.

N80-23365*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COOLING OF HIGH PRESSURE ROCKET THRUST CHAMBERS WITH LIQUID OXYGEN

H. G. Price 1980 15 p refs Proposed for presentation at the 16th Joint Propulsion Conf., Hartford, 30 Jun. - 2 Jul. 1980; cosponsored by AIAA, ASME and SAE

(NASA-TM-81503; E-441) Avail: NTIS HC A02/MF A01 CSCL 21H

An experimental program using hydrogen and oxygen as the propellants and supercritical liquid oxygen (LOX) as the coolant was conducted at 4.14 and 8.274 MN/square meters (600 and 1200 psia) chamber pressure. Data on the following are presented: the effect of LOX leaking into the combustion region through small cracks in the chamber wall; and verification of the supercritical oxygen heat transfer correlation developed from heated tube experiments; A total of four thrust chambers with throat diameters of 0.066 m were tested. Of these, three were cyclically tested to 4.14 MN/square meters (600 psia) chamber pressure until a crack developed. One had 23 additional hot cycles accumulated with no apparent metal burning or distress. The fourth chamber was operated at 8.274 MN/square meters (1200 psia) pressure to obtain steady state heat transfer data. Wall temperature measurements confirmed the heat transfer correlation. R.C.T.

N80-30382* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYTICAL INVESTIGATION OF TWO HYDROGEN-OXYGEN ROCKET ENGINE SYSTEMS FOR LOW-THRUST APPLICATION

Dean D. Scheer *In* APL The 1980 JANNAF Propulsion Meeting, Vol. 5 Mar. 1980 p 1-20 refs (For primary document see N80-30381 21-20)

Avail: Issuing Activity CSCL 21H

Two hydrogen-oxygen rocket engine system concepts were analyzed parametrically over a thrust range from 100 to 1000 pounds and a chamber pressure range from 175 to 1000 psia. Both concepts were regeneratively cooled with hydrogen and were pump fed by electric motor driven positive displacement pumps. Electric power was provided by either a turboalternator (turboalternator concept) or some means external to the engine system (auxiliary power concept). The computer program used to conduct the analyses along with the design characteristics of the major engine system components are briefly described. The feasible design range of the systems over the parametric range of thrust is discussed in terms of allowable chamber pressure considering the constraints of thrust chamber cooling and cycle power. Engine system estimated performance, mass, and dimensional envelope parametric data within the feasible design range are presented. Author

N80-30383* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LeRC REDUCED GRAVITY FLUID MANAGEMENT TECHNOLOGY PROGRAM

J. C. Aydelott and E. P. Symons *In* APL The 1980 JANNAF Propulsion Meeting, Vol. 5 Mar. 1980 p 21-34 refs (For primary document see N80-30381 21-20)

Avail: Issuing Activity CSCL 21H

An overview of studies addressing reduced gravity fluid management problems using scale model propellant tanks in drop towers that provided up to five seconds of reduced gravity test time is given. The Cryogen Fluid Management Experiment designed to provide an orbital evaluation of a subcritical liquid hydrogen storage and supply as part of the shuttle/Spacelab program is described. An experiment to study orbital transfer of liquids and a Spacelab facility capable of housing multiple fluid dynamic and heat transfer experiments are also discussed. Progress in the analytical evaluation of propellant management systems for both low and high thrust orbit transfer propulsion systems and the development of computer techniques for simulating reduced gravity fluid dynamic processes is reported. J.M.S.

N80-30386* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

UPPER STAGES UTILIZING ELECTRIC PROPULSION

David C. Byers *In* APL The 1980 JANNAF Propulsion Meeting, Vol. 5 Mar. 1980 p 69-84 refs (For primary document see N80-30381 21-20)

Avail: Issuing Activity CSCL 21H

The payload capabilities of upper stages using electric propulsion for a LEO to GEO orbit transfer mission are presented. The impact on payloads of total mass in LEO, thrusting (trip) time, propellant type, specific impulse, and power source characteristics was evaluated. Dependent upon detailed assumptions, electric stages were found capable of delivering payloads in thrusting time less than 50 days with payloads always initially increasing rapidly with increasing thrusting times. For the shorter thrusting (trip) times the payloads increased with increasing propellant mass and decreasing specific impulse. At very long trip times, however, the payload increased with decreasing propellant mass and increasing specific impulse. Variation of the specific mass of the power source between 5 and 30 kg/kW caused the minimum trip times to vary about a factor of three and at short trip times strongly affected the electric stage payload capabilities. J.M.S.

N80-31449*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LARGE SPACE SYSTEMS/LOW-THRUST PROPULSION TECHNOLOGY

Jul. 1980 347 p refs Meeting held at Cleveland, 20-21 May 1980

(NASA-CP-2144; E-510) Avail: NTIS HC A15/MF A01 CSCL 21H

The potentially critical interactions that occur between propulsion, structures and materials, and controls for large-spacecraft are considered, the technology impacts within these fields are defined and the net effect on large systems and the resulting missions is determined. Topical areas are systems/mission analysis, LSS static and dynamic characterization, and propulsion systems characterization. For individual titles, see N80-31450 through N80-31471.

N80-31452*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELECTRIC PROPULSION TECHNOLOGY

Robert C. Finke *In its* Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 23-30 (For primary document see N80-31449 22-20)

Avail: NTIS HC A15/MF A01 CSCL 21H

The advanced electric propulsion program is directed towards lowering the specific impulse and increasing the thrust per unit of ion thruster systems. In addition, electrothermal and electromagnetic propulsion technologies are being developed to attempt to fill the gap between the conventional ion thruster and chemical rocket systems. Most of these new concepts are exagenous and are represented by rail accelerators, ablative Teflon thrusters, MPD arcs, Free Radicals, etc. Endogenous systems such as metallic hydrogen offer great promise and are also being pursued. A.R.H.

N80-31453*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
CHEMICAL PROPULSION TECHNOLOGY
Richard J. Priem *In its* Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 31-36 (For primary document see N80-31449 22-20)
Avail: NTIS HC A15/MF A01 CSCL 21H

An overview of NASA's low thrust liquid chemical propulsion program is presented with particular emphasis on thrust system technology in the ten to one thousand pound thrust range. Key technology issues include high performance of cooled low thrust engines, small cryogenic pumps; multiple starts-shutdowns (10) with slow ramps (approximately 10 seconds); thrust variation - 4/1 in flight and 20/1 between flights; long life (100 hours); improved system weight and size, and propellant selection.
A.R.H.

N80-31454*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LSS/PROPULSION INTERACTIONS STUDIES
Omer F. Spurlock *In its* Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 37-52 (For primary document see N80-31449 22-20)
Avail: NTIS HC A15/MF A01 CSCL 21H

Interactions between the LSS and the propulsion system are large, significant, interrelated, and complex. Issues and problems in interfacing include the effects on the structure from static, dynamic, and launch loads, control, thrust distribution, throttling, and the environment. Control interaction, the disposal of debris/obsolete spacecraft, and the constraints of launch to low Earth orbit must also be considered. A.R.H.

N80-31457*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LOW-THRUST VEHICLE CONCEPT STUDIES
George R. Smolak *In its* Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 97-106 (For primary document see N80-31449 22-20)
Avail: NTIS HC A15/MF A01 CSCL 21H

Part of NASA's orbit transfer vehicle propulsion program is devoted to the development of analytical tools to define propulsion system performance, weight, size, and other parameters, and to develop packing concepts for LSS mission propulsion and payload systems. Packing studies discussed relate to shuttle cargo bay constraints; low thrust engine profile and performance; large space frame concept and weight; low thrust vehicles stowed in shuttle, LSS payload capability, and weight distribution. Further study is needed to determine interactions among propulsion system, payload structures, and shuttle. Low thrust-to-weight ratios are desirable to maximize payload weights and deployed areas. A.R.H.

N80-31471*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADVANCED CONCEPTS
Bruce A. Banks *In its* Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 337-342 (For primary document see N80-31449 22-20)
Avail: NTIS HC A15/MF A01 CSCL 21H

The relative strengths of those interactions which enable propulsive forces are listed as well as the specific impulse of various propellants. Graphics show the linear synchronous motor of the mass driver, the principle of the direct current electromagnetic launcher, and the characteristics of the rail gun. A.R.H.

N80-33465*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SYNCHRONOUS ENERGY TECHNOLOGY
Sep. 1980 144 p Symp. held in Cleveland, 29-30 Apr. 1980 (NASA-CP-2154; E-469) Avail: NTIS HC A07/MF A01 CSCL 21H

The synchronous technology requirements for large space power systems are summarized. A variety of technology areas including photovoltaics, thermal management, and energy storage, and power management are addressed. For individual titles, see N80-33466 through N80-33475.

N80-33466*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SYNCHRONOUS ENERGY TECHNOLOGY PROGRAM
Robert C. Finke *In its* Synchronous Energy Technol. Sep. 1980 p 1-7 (For primary document see N80-33465 24-20)
Avail: NTIS HC A07/MF A01 CSCL 10B

The power program in NASA and DOD are discussed with emphasis on the technology for future large space power systems. The structure of the synchronous energy technology program is described and the technologies required for future geosynchronous power stations are defined. The output of the program is to be a series of design data documents to provide design information and to transfer the technology to the involved community. R.C.T.

N80-33470*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC TECHNOLOGY DEVELOPMENT FOR SYNCHRONOUS ORBIT
Henry W. Brandhorst *In its* Synchronous Energy Technol. Sep. 1980 p 45-56 (For primary document see N80-33465 24-20)
Avail: NTIS HC A07/MF A01 CSCL 10A

Accomplishments and expected benefits are summarized for the following efforts: (1) achieving silicon solar cell efficiency of 18% at 200 micron m to 250 micron m thickness; (2) reducing silicon cell radiation damage in geosynchronous orbit after 10 years to less than 15%; (3) demonstrating coplanar back contact 50 micron m thick silicon solar cells with efficiency of 14%; (4) demonstrating the feasibility of a radiation tolerant GaAs concentrator cell; (5) achieving 30% efficient photo conversion in the laboratory; (6) defining candidate concepts for 50% efficient electromagnetic conversion; and (7) demonstrating the technology for protecting arrays capable of > 300W/kg after 10 years in geosynchronous orbit. A.R.H.

A80-10376 * # **Characteristics of primary electric propulsion systems.** D. C. Byers (NASA, Lewis Research Center, Electric Thruster Section, Cleveland, Ohio). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2041.* 13 p. 21 refs.

The use of advanced electric propulsion systems will provide cost and performance benefits for future energetic space missions. A methodology to predict the characteristics of advanced electric propulsion systems was developed and programmed for computer calculations to allow evaluation of a broad set of technology and mission assumptions. The impact on overall thrust system characteristics was assessed for variations of propellant type, total accelerating voltage, thruster area, specific impulse, and power system approach. The data may be used both to provide direction to technology emphasis and allow for preliminary estimates of electric propulsion system properties for a wide variety of application. (Author)

A80-10384 * # **Sputtering in mercury ion thrusters.** M. A. Mantenieks and V. K. Rawlin (NASA, Lewis Research Center, Cleveland, Ohio). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2061.* 13 p. 48 refs.

Ground-based tests of Hg ion thrusters have identified sputter erosion of thruster components as one of the main life limiting phenomena. Subsequent measurements have revealed that sputtering rates can be affected by background gases at pressures as low as 10 to the -10th torr. With the recent interest in thin film technology, sputtering in the presence of reactive gases has been studied in great detail. This paper presents the results of many of those studies and applies them to the sputtering of electric thrusters. A model, which assumes that chemisorption is the dominant mechanism, is applied to the sputtering rate measurements of the screen grid of a 30-cm thruster in the presence of nitrogen. The model utilizes inputs from a variety of experimental and analytical sources. The model of environmental effects on sputtering was applied to thruster conditions of low discharge voltage and a discussion of the comparison of theory and experiment is presented. (Author)

A80-10386 * # **SERT II 1979 extended flight thruster system performance.** W. R. Kerslake and L. R. Ignaczak (NASA, Lewis Research Center, Cleveland, Ohio). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2063.* 13 p. 9 refs.

The SERT II spacecraft, launched in 1970, has been maintained in an operational, but intermittently active status since 1971. Periodic thruster status has been reported while waiting for normal orbit precession to return the spacecraft to continuous sunlight in 1979. Now, the thruster has been operated for 600 hours in the first quarter of 1979. Thruster startup and operation in 1979 is unchanged after 9 years in space. The ion thruster was gimbaled and used to maintain spin stabilization of the spacecraft. Minor components of the spacecraft have failed, but have not interfered with the functional status of the spacecraft. (Author)

A80-10387 * # **Neutralization tests on the SERT II spacecraft.** W. R. Kerslake and S. Domitz (NASA, Lewis Research Center, Cleveland, Ohio). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2064.* 15 p. 11 refs.

Orbit precession returned the SERT II spacecraft to continuous sunlight in January 1979 for the first time since early 1972, and new experiments were planned and conducted. Neutralization of an ion beam was accomplished by a second neutralizer cathode located 1 meter away. Plasma potential measurements were made of the plasma surrounding the ion beam and connecting the beam to the second neutralizer. When the density of the connecting plasma was increased by turning on the main discharge of a neighboring ion thruster, the neutralization of the ion beam occurred with improved (lower) coupling voltage. These and other tests reported should aid in the future design of spacecraft using electric thruster systems. Data taken indicate that cross neutralization of ion thrusters in a multiple thruster array should occur readily. (Author)

A80-10392 * # **Reduced power processor requirements for the 30-cm diameter HG ion thruster.** V. K. Rawlin (NASA, Lewis Research Center, Cleveland, Ohio). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2081.* 10 p. 25 refs.

The characteristics of power processors strongly impact the overall performance and cost of electric propulsion systems. A program was initiated to evaluate simplifications of the thruster-power processor interface requirements. The power processor requirements are mission dependent with major differences arising for those missions which require a nearly constant thruster operating point (typical of geocentric and some inbound planetary missions) and those requiring operation over a large range of input power (such as outbound planetary missions). This paper describes the results of tests which have indicated that as many as seven of the twelve power supplies may be eliminated from the present Functional Model Power Processor used with 30-cm diameter Hg ion thrusters. (Author)

A80-20957 * # **Design and evaluation of high performance rocket engine injectors for use with hydrocarbon fuels.** A. J. Pavli (NASA, Lewis Research Center, Cleveland, Ohio). *Joint-Army-Navy-NASA-Air Force Interagency Propulsion Committee, Combustion Conference, 16th, Monterey, Calif., Sept. 10-14, 1979, Paper.* 18 p.

An experimental program to determine the feasibility of using a heavy hydrocarbon fuel as a rocket propellant is reported herein. A method of predicting performance of a heavy hydrocarbon in terms of vaporization effectiveness is described and compared to other fuels and to experimental test results. The work was done at a chamber pressure of 4137 KN/sq M (600 psia) with RP-1, JP-10, and liquefied natural gas as fuels, and liquid oxygen as the oxidizer. Combustion length effects were explored over a range of 21.6 cm (8 1/2 in.) to 55.9 cm (22 in.). Four injector types were tested, each over a range of mixture ratios. Further configuration modifications were obtained by 'reaming' each injector several times to provide test data over a range of injector pressure drop. (Author)

A80-20959 * # **HG ion thruster component testing.** M. A. Mantenieks (NASA, Lewis Research Center, Cleveland, Ohio). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2116.* 13 p. 20 refs.

Cathodes, isolators, and vaporizers are critical components in determining the performance and lifetime of mercury ion thrusters. The results of life tests of several of these components are reported. A 30-cm thruster CIV test in a bell jar has successfully accumulated over 26,000 hours. The cathode has undergone 65 restarts during the life test without requiring any appreciable increases in starting power. Recently, all restarts have been achieved with only the 44 volt keeper supply with no change required in the starting power. Another ongoing 30-cm Hg thruster cathode test has successfully passed the 10,000 hour mark. A solid-insert, 8-cm thruster cathode has accumulated over 4,000 hours of thruster operation. All starts have been achieved without the use of a high voltage ignitor. The results of this test indicate that the solid impregnated insert is a viable neutralizer cathode for the 8-cm thruster. (Author)

A80-29989 * # **Upper stages utilizing electric propulsion.** D. C. Byers (NASA, Lewis Research Center, Cleveland, Ohio). *Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee, Propulsion Meeting, Monterey, Calif., Mar. 11-13, 1980, Paper.* 19 p. 23 refs.

The payload capabilities of upper stages using electric propulsion for a LEO to GEO orbit transfer mission are discussed. Payloads are calculated using an established methodology which employs assumptions concerning state-of-the-art electric propulsion technology. The effects on payloads are examined for variations of total mass in LEO (MLEO), thrusting (trip) times, propellant type, specific impulse, and power source specific mass. It is found that the ratios of payload masses to total mass in LEO are insensitive to MLEO, which allows a highly condensed presentation of the overall payload capability. Electric stages are shown capable of delivering payloads in thrusting times less than 50 days with the payloads increasing rapidly with increase in thrusting times. Payload capabilities exceeding those attainable with chemical propulsion are possible using state-of-the-art electric propulsion technology. L.M.

A80-32886 * # **Electric propulsion, circa 2000.** W. R. Hudson (NASA, Washington, D.C.) and R. C. Finke (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, International Meeting and Technical Display on Global Technology 2000, Baltimore, Md., May 6-8, 1980, Paper 80-0912.* 6 p.

This paper discusses the future of electric propulsion, circa 2000. Starting with the first generation Solar Electric Propulsion (SEP) technology as the first step toward the next century's advanced propulsion systems, the current status and future trends of other systems such as the magnetoplasmadynamic accelerator, the mass driver, the laser propulsion system, and the rail gun are described. (Author)

A80-33850 * **Origin of reverse annealing in radiation-damaged silicon solar cells.** I. Weinberg and C. K. Swartz (NASA, Lewis Research Center, Cleveland, Ohio). *Applied Physics Letters,* vol. 36, Apr. 15, 1980, p. 693-695. 12 refs.

The paper employs relative defect concentrations, energy levels, capture cross sections, and minority carrier diffusion lengths in order to identify the defect responsible for the reverse annealing observed in a radiation damaged n(+)/p silicon solar cell. It is reported that the responsible defect, with the energy level at +0.30 eV, has been tentatively identified as boron-oxygen-vacancy complex. In conclusion, it is shown that removal of this defect could result in significant cell recovery when annealing at temperatures well below the currently required 400 C. M.E.P.

A80-35503 * # **Analytical investigation of two hydrogen-oxygen rocket engine systems for low-thrust application.** D. D. Scheer (NASA, Lewis Research Center, Cleveland, Ohio). *Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee, Propulsion Meeting, Monterey, Calif., Mar. 11-13, 1980, Paper.* 15 p. 11 refs.

Two hydrogen-oxygen rocket engine system concepts were analyzed parametrically over a thrust range from 100 to 1000 pounds and a chamber pressure range from 175 to 1000 psia. Both concepts were regeneratively cooled with hydrogen and were pump-fed by electric motor driven positive displacement pumps. Electric power was provided by either a turboalternator (turboalternator concept) or some means external to the engine system (auxiliary power concept). The computer program used to conduct the analyses along with the design characteristics of the major engine system components are briefly described. The feasible design range of the systems over the parametric range of thrust is discussed in terms of allowable chamber pressure considering the constraints of thrust chamber cooling and cycle power. Engine system estimated performance, mass, and dimensional envelope parametric data within the feasible design range are presented. (Author)

A80-38908 * # **Capillary device refilling.** M. H. Blatt, F. Merino (General Dynamics Corp., Convair Div., San Diego, Calif.), and E. P. Symons (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1095.* 8 p. Contract No. NAS3-20092.

An analytical and experimental study was conducted dealing with refilling start baskets (capillary devices) with settled fluid. A computer program was written to include dynamic pressure, screen wicking, multiple-screen barriers, standpipe screens, variable vehicle mass for computing vehicle acceleration, and calculation of tank outflow rate and vapor pullthrough height. An experimental apparatus was fabricated and tested to provide data for correlation with the analytical model; the test program was conducted in normal gravity using a scale-model capillary device and ethanol as the test fluid. The test data correlated with the analytical model; the model is a versatile and apparently accurate tool for predicting start basket refilling under actual mission conditions. A.T.

A80-38975 * # **Nuclear electric propulsion system utilization for earth orbit transfer of large spacecraft structures.** T. H. Silva (Aerospace Corp., El Segundo, Calif.) and D. C. Byers (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1223.* 13 p. 17 refs.

The paper discusses a potential application of electric propulsion to perform orbit transfer of a large spacecraft structure to geosynchronous orbit (GEO) from LEO, utilizing a nuclear reactor space power source in the spacecraft on a shared basis. The discussions include spacecraft, thrust system, and nuclear reactor space power system concepts. Emphasis is placed on orbiter payload arrangements, spacecraft launch constraints, and spacecraft LEO assembly and deployment sequences. V.T.

A80-38992 * # **Cooling of high pressure rocket thrust chambers with liquid oxygen.** H. G. Price (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1260.* 10 p. 9 refs.

An experimental program using hydrogen and oxygen as the propellants and supercritical liquid oxygen (LOX) as the coolant was conducted at 4.14 and 8.274 MN/sq m chamber pressure. It was aimed to demonstrate the effect of LOX leaking into the combustion region through small cracks in the chamber wall, and to verify the supercritical oxygen heat transfer correlation developed from heated tube experiments. Four thrust chambers with throat diameters of 0.066 m were tested; three of these were cyclically tested to 4.14 MM/sq m chamber pressure until a crack developed; the fourth chamber was operated at 8.274 MM/sq m pressure to obtain steady state heat transfer data. Wall temperature measurements confirmed the heat transfer correlation. A.T.

A80-38994 * # **Advanced cooling techniques for high-pressure, hydrocarbon-fueled rocket engines.** R. T. Cook (Rockwell International Corp., Canoga Park, Calif.) and R. J. Quentmeyer (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1266.* 11 p. 7 refs. Contract No. NAS3-21381.

The regenerative cooling limits (maximum chamber pressure) are defined for oxygen/hydrocarbon (Methane, Propane, and RP-1) rocket engines over a thrust range of 20,000 to 600,000 lbf for a reusable life of 250 missions. Chamber pressure limits are first defined without a hot-gas wall carbon layer (unenhanced designs). Cooling enhancement chamber pressure limits are then established for seven thermal barriers (carbon layer, ceramic coating, graphite liner, film cooling, zoned combustion, transpiration cooling, and a combination of two of the above). The maximum regenerative-cooled chamber pressure is attained with the oxygen/methane propellant combination. (Author)

A80-48357 * # **Power management for multi-100 KWe space systems.** J. W. Mildice (General Dynamics Corp., Convair Div., San Diego, Calif.) and M. E. Valgora (NASA, Lewis Research Center, Cleveland, Ohio). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 2. (A80-48165 21-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 1401-1405. Contract No. NAS3-21757.

This paper examines mid to late 1980s power management technology needs to support development of a general-purpose space platform, capable of supplying 100 to 250 KWe to a variety of users in LEO. To that end, a typical Shuttle-assembled and supplied space platform is described, along with a group of payloads which might reasonably be expected to use such a facility. Examination of platform and user power needs yields a set of power system requirements used to evaluate power management options for life cycle cost effectiveness. The most cost-effective AC/DC and DC systems are evaluated, specifically to develop system details which lead to technology goals including array and transmission voltage, best frequency for AC power transmission, and advantages and disadvantages of AC and DC systems for this application. Finally, system and component requirements are compared with the state of the art to identify areas where technology development is required. (Author)

N80-11137*# TRW Defense and Space Systems Group, Redondo Beach, Calif.

SPECIFIC SPACECRAFT EVALUATION: SPECIAL REPORT Special Report, 1 Nov. 1977 - 1 Jun. 1978

J. M. Sellen, Jr. 1 Nov. 1978 211 p

(Contract NAS3-21047)

(NASA-CR-159420) Avail: NTIS HC A10/MF A01 CSCL 21H

Charged and neutral particle transport from an 8 cm mercury ion thruster to the surfaces of the P 80-1 spacecraft and to the

Teal Ruby sensor and the ECOM 501 sensor of that spacecraft were investigated. Laboratory measurements and analyses were used to examine line-of-sight and nonline-of sight particle transport modes. The recirculation of Hg(+) ions in the magnetic field of the earth was analyzed for spacecraft velocity and Earth magnetic field vector configurations which are expected to occur in near Earth, circular, high inclination orbits. For these magnetic field and orbit conditions and for expected ion release distribution functions, in both angles and energies, the recirculation/re-interception of ions on spacecraft surfaces was evaluated. The refraction of weakly energetic ions in the electric fields of the thruster plasma plume and in the electric fields between this plasma plume and the material boundaries of the thruster, the thruster sputter shield, and the various spacecraft surfaces were examined. The neutral particle transport modes of interest were identified as sputtered metal atoms from the thruster beam shield. Results, conclusions, and future considerations are presented. R.C.T.

N80-13158*# Hughes Research Labs., Malibu, Calif.
PRIMARY ELECTRIC PROPULSION TECHNOLOGY STUDY Final Report, 13 Sep. 1977 - 13 Jun. 1979
R. L. Poeschel and J. R. Beattie Nov. 1979 186 p refs
(Contract NAS3-21040)
(NASA-CR-159688) Avail: NTIS HC A09/MF A01 CSCL 01C

An investigation of the 30-cm engineering-model-thruster technology with emphasis placed on the development of models for understanding and predicting the operational characteristics and wear-out mechanisms of the thruster as a function of operating or design parameters is presented. The task studies include: (1) the wear mechanisms and wear rates that determine the useful lifetime of the thruster discharge chamber; (2) cathode lifetime as determined by the depletion of barium from the barium-aluminate-impregnated-porous-tungsten insert that serves as a barium reservoir; (3) accelerator-grid-system technology; (4) a verification of the high-voltage propellant-flow-electrical-isolator design developed under NASA contract NAS3-20395 for operation at 10-kV applied voltage and 10-A equivalent propellant flow with mercury and argon propellants. A model was formulated for predicting performance. M.M.M.

N80-13164*# Tennessee Technological Univ., Cookeville. Dept. of Engineering Science.
ANALYSIS OF COMBUSTION INSTABILITY IN LIQUID FUEL ROCKET MOTORS Ph.D. Thesis
Kin-Wing Wong and M. Ventrice Nov. 1979 119 p refs
(Grant NGR-43-003-015)
(NASA-CR-159733) Avail: NTIS HC A06/MF A01 CSCL 21H

The development of a technique to be used in the solution of nonlinear velocity-sensitive combustion instability problems is described. The orthogonal collocation method was investigated. It found that the results are heavily dependent on the location of the collocation points and characteristics of the equations, so the method was rejected as unreliable. The Galerkin method, which has proved to be very successful in analysis of the pressure sensitive combustion instability was found to work very well. It was found that the pressure wave forms exhibit a strong second harmonic distortion and a variety of behaviors are possible depending on the nature of the combustion process and the parametric values involved. A one-dimensional model provides further insight into the problem by allowing a comparison of Galerkin solutions with more exact finite-difference computations. A.R.H.

N80-13165*# Tennessee Technological Univ., Cookeville.
STABILITY ANALYSIS OF A LIQUID FUEL ANNULAR COMBUSTION CHAMBER M.S. Thesis
G. H. McDonald Nov. 1978 151 p refs
(Grant NGR-43-003-015)
(NASA-CR-159734) Avail: NTIS HC A08/MF A01 CSCL 21H

High frequency combustion instability problems in a liquid fuel annular combustion chamber are examined. A modified Galerkin method was used to produce a set of modal amplitude equations from the general nonlinear partial differential acoustic wave equation in order to analyze the problem of instability. From these modal amplitude equations, the two variable perturbation method was used to develop a set of approximate equations of a given order of magnitude. These equations were modeled to show the effects of velocity sensitive combustion instabilities by evaluating the effects of certain parameters in the given set of equations. A.W.H.

N80-14189*# Aerojet Liquid Rocket Co., Sacramento, Calif.
PERFORMANCE OF A TRANSPIRATION-REGENERATIVE COOLED ROCKET THRUST CHAMBER Final Report
H. W. Valler Sep. 1979 414 p refs
(Contract NAS3-21029)
(NASA-CR-159742) Avail: NTIS HC A18/MF A01 CSCL 21H

The analysis, design, fabrication, and testing of a liquid rocket engine thrust chamber which is gas transpiration cooled in the high heat flux convergent portion of the chamber and water jacket cooled (simulated regenerative) in the barrel and divergent sections of the chamber are described. The engine burns LOX-hydrogen propellants at a chamber pressure of 600 psia. Various transpiration coolant flow rates were tested with resultant local hot gas wall temperatures in the 800 F to 1400 F range. The feasibility of transpiration cooling with hydrogen and helium, and the use of photo-etched copper platelets for heat transfer and coolant metering was successfully demonstrated. A.R.H.

N80-17137*# Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering.
PHYSICAL PHENOMENA IN MERCURY ION THRUSTERS Annual Report, 1 Dec. 1978 - 1 Dec. 1979
Paul J. Wilbur Dec. 1979 146 p refs
(Grant NGR-06-002-112)
(NASA-CR-159784) Avail: NTIS HC A07/MF A01 CSCL 21C

Experimental tests results demonstrating that reductions in screen grid thickness enhance the performance of ion thruster grids are presented. Shaping of the screen hole cross section is shown on the other hand not to affect performance substantially. The effect of the magnetic field in the vicinity of the hollow cathode on cathode performance is studied and test results are presented that show reductions in keeper voltages of a few volts can be realized by judicious applications of fields on the order of 100 gauss. The plasma downstream of a SERT 2 thruster operating without high voltage is studied. A model describing electron escape from the thruster under these conditions is discussed. A model defining the performance of the baffle aperture of an ion thruster is refined and experimental verification of the model is undertaken. Author

N80-17141*# Rocketdyne, Canoga Park, Calif.
ADVANCED COOLING TECHNIQUES FOR HIGH-PRESSURE HYDROCARBON-FUELED ENGINES Final Report, Aug. 1978 - Oct. 1979
R. T. Cook Oct. 1979 230 p refs
(Contract NAS3-21381)
(NASA-CR-159790; RI/RD79-310) Avail: NTIS HC A11/MF A01 CSCL 21H

The regenerative cooling limits (maximum chamber pressure) for O2/hydrocarbon gas generator and staged combustion cycle rocket engines over a thrust range of 89,000 N (20,000 lbf) to 2,669,000 N (600,000 lbf) for a reusable life of 250 missions were defined. Maximum chamber pressure limits were first determined for the three propellant combinations (O2/CH4, O2/C3H8, and O2/RP-1 without a carbon layer (unenhanced designs). Chamber pressure cooling enhancement limits were then established for seven thermal barriers. The thermal barriers evaluated for these designs were: carbon layer, ceramic coating, graphite liner, film cooling, transpiration cooling, zoned combustion, and a combination of two of the above. All fluid barriers were assessed a 3 percent performance loss. Sensitivity studies were then conducted to determine the influence of cycle life and RP-1 decomposition temperature on chamber pressure limits Chamber and nozzle design parameters are presented for the unenahanced and enhanced designs The maximum regenerative cooled chamber pressure limits were attained with the O2/CH4 propellant combination The O2/RP-1 designs relied on a carbon layer and liquid gas injection chamber contours, short chamber, to be competitive with the other two propellant combinations This was attributed to the low decomposition temperature of RP-1 R C T

N80-15202*# Rocketdyne, Canoga Park, Calif
LIQUID OXYGEN/LIQUID HYDROGEN AUXILIARY POWER SYSTEM THRUSTER INVESTIGATION Final Report, Oct. 1976 - Feb. 1979
E E Eberle and L Kusak Dec 1979 186 p refs
(Contract NAS3-20373)
(NASA-CR-159674; RI/RD79-217) Avail NTIS HC A09/MF A01 CSCL 21H

The design, fabrication, and demonstration of a 111 newton (25 lb) thrust, integrated auxiliary propulsion system (IAPS) thruster for use with LH2/LO2 propellants is described Hydrogen was supplied at a temperature range of 22 to 33 K (40 to 60 R), and oxygen from 89 to 122 K (160 to 220 R) The thruster was designed to operate in both pulse mode and steady-state modes for vehicle attitude control, space maneuvering, and as an abort backup in the event of failure of the main propulsion system A dual sleeve, tri axial injection system was designed that utilizes a primary injector/combustor where 100 percent of the oxygen and 8 percent of the hydrogen is introduced, a secondary injector/combustor where 45 percent of the hydrogen is introduced to mix with the primary combustor gases, and a boundary layer injector that uses the remaining 45 percent of the hydrogen to cool the thrust throat/nozzle design Hot-fire evaluation of this thruster with a BLC injection distance of 2 79 cm (1 10 in) indicated that a specific impulse value of 390 sec can be attained using a coated molybdenum thrust chamber Pulse mode tests indicated that a chamber pressure buildup to 90 percent thrust can be achieved in a time on the order of 48 msec Some problems were encountered in achieving ignition of each pulse during pulse trains This was interpreted to indicate that a higher delivered spark energy level (> 100 mJ) would be required to maintain ignition reliability of the plasma torch ignition system under the extra 'cold' conditions resulting during pulsing Author

N80-16096*# Boeing Aerospace Co., Seattle, Wash.
ELECTRIC PROPULSION FOR NEAR-EARTH SPACE MISSIONS Final Report, Feb. 1978 - Apr. 1979
C. H. Terwilliger and W. W. Smith Jan 1980 206 p
(Contract NAS3-21346)
(NASA-CR-159735; D180-25475-1) Avail NTIS HC A10/MF A01 CSCL 21C

A set of missions was postulated that was considered to be representative of those likely to be desirable/feasible over the next three decades. The characteristics of these missions, and their payloads, that most impact the choice/design of the requisite propulsion system were determined. A system-level model of the near-Earth transportation process was constructed, which incorporated these mission/system characteristics, as well as the fundamental parameters describing the technology/performance of an ion bombardment based electric propulsion system. The model was used for sensitivity studies to determine the interactions between the technology descriptors and program costs, and to establish the most cost-effective directions for technology advancement. The most important factor was seen to be the costs associated with the duration of the mission, and this in turn makes the development of advanced electric propulsion systems having moderate to high efficiencies (> 50 percent) at intermediate ranges of specific impulse (approximately 1000 seconds) very desirable. Author

N80-19185*# General Dynamics/Convair, San Diego, Calif.
CAPILLARY ACQUISITION DEVICES FOR HIGH-PERFORMANCE VEHICLES: EXECUTIVE SUMMARY
M. H. Blatt, R. D Bradshaw, and J. A. Risberg Feb. 1980 103 p refs
(Contract NAS3-20092)
(NASA-CR-159658; GDC-CRAD-80-003) Avail NTIS HC A06/MF A01 CSCL 21H

Technology areas critical to the development of cryogenic capillary devices were studied Passive cooling of capillary devices was investigated with an analytical and experimental study of wicking flow Capillary device refilling with settled fluid was studied using an analytical and experimental program that resulted in successful correlation of a versatile computer program with test data The program was used to predict Centaur D-1S LO2 and LH2 start basket refilling Comparisons were made between the baseline Centaur D-1S propellant feed system and feed system alternatives including systems using capillary devices The preferred concepts from the Centaur D-1S study were examined for APOTV and POTV vehicles for delivery and round trip transfer of payloads between LEO and GEO Mission profiles were determined to provide propellant usage timelines and the payload partials were defined A.W.H.

N80-24362*# Colorado State Univ., Fort Collins. Dept. Of Mechanical Engineering
INERT GAS THRUSTERS Annual Report
Harold R. Kaufman and Raymond S. Robinson Nov. 1979 113 p refs
(Grant NsG-3011)
(NASA-CR-159813) Avail: NTIS HC A06/MF A01 CSCL 21C

Inert gas thrusters considered for space propulsion systems were investigated. Electron diffusion across a magnetic field was examined utilizing a basic model. The production of doubly charged ions was correlated using only overall performance parameters. The use of this correlation is therefore possible in the design stage of large gas thrusters, where detailed plasma properties are not available. Argon hollow cathode performance was investigated over a range of emission currents, with the positions of the inert, keeper, and anode varied. A general trend observed was that the maximum ratio of emission to flow rate increased at higher propellant flow rates. It was also found that an enclosed keeper enhances maximum cathode emission at high flow rates. The maximum cathode emission at a given flow rate was associated with a noisy high voltage mode. Although this mode has some similarities to the plume mode found at low flows and emissions, it is encountered by being initially in the spot mode and increasing emission. A detailed analysis of large, inert-gas thruster performance was carried out. For maximum thruster efficiency, the optimum beam diameter increases from less than a meter at under 2000 sec specific impulse to several meters at 10,000 sec. The corresponding range in input power ranges from several kilowatts to megawatts. J.M.S.

N80-27424*# Xerox Electro-Optical Systems, Pasadena, Calif.
INERT GAS ION THRUSTER DEVELOPMENT Interim Report, Apr. 1978 - Feb. 1979
William D. Ramsey Mar. 1980 99 p refs
(Contract NAS3-21345)
(NASA-CR-159805; XEOS-2372; IR-1) Avail: NTIS HC A05/MF A01 CSCL 21C

Two 12 cm magneto-electrostatic containment (MESC) ion thrusters were performance mapped with argon and xenon. The first, hexagonal, thruster produced optimixed performance of 48.5 to 79 percent argon mass utilization efficiencies at discharge energies of 240 to 425 eV/ion, respectively. Xenon mass utilization efficiencies of 78 to 95 percent were observed at discharge energies of 220 to 290 eV/ion with the same optimized hexagonal thruster. Changes to the cathode baffle reduced the discharge anode potential during xenon operation from approximately 40 volts to about 30 volts. Preliminary tests conducted with the second, hemispherical, MESC thruster showed a nonuniform anode magnetic field adversely affected thruster performance. This performance degradation was partially overcome by changes in the boundary anode placement. Conclusions drawn the hemispherical thruster tests gave insights into the plasma processes in the MESC discharge that will aid in the design of future thrusters. Author

N80-30384* Rockeldyne, Canoga Park, Calif.
LEO-TO-GEO LOW THRUST CHEMICAL PROPULSION
J. M. Shoji *In* APL The 1980 JANNAF Propulsion Meeting, Vol 5 Mar. 1980 p 35-51 refs (For primary document see N80-30381 21-20)
(Contract NAS3-21941)
Avail: Issuing Activity CSCL 21H

One approach being considered for transporting large space structures from low Earth orbit (LEO) to geosynchronous equatorial orbit (GEO) is the use of low thrust chemical propulsion systems. A variety of chemical rocket engine cycles evaluated for this application for oxygen/hydrogen and oxygen/hydrocarbon propellants (oxygen/methane and oxygen/RF-1) are discussed. These cycles include conventional propellant turbine drives, turboalternator/electric motor pump drive, and fuel cell/electric motor pump drive as well as pressure fed engines. Thrust chamber cooling analysis results are presented for regenerative/radiation and film/radiation cooling. J.M.S.

N80-31455*# Martin Marietta Corp., Bethesda, Md.
DOD LOW-THRUST MISSION STUDIES
William E. Pipes *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 53-71 (For primary document see N80-31449 22-20)
(Contract F04611-79-C-0032)
Avail: NTIS HC A15/MF A01 CSCL 21H

The space transportation system (STS) will be the principal means of launching USAF spacecraft beginning in the 1980's. Since it is manned and reusable it provides new opportunities for unique approaches for cost effective utilization of its capabilities. The STS also places additional requirements and constraints on advanced spacecraft deployment systems that did not previously exist for expandable launch vehicles. To fully utilize these new capabilities designers must be prepared by having cost effective technologies available. Advanced propulsion technology that would provide flexibility, performance, and economic benefits to future Air Force missions was identified. Both electric and chemical propulsion systems are discussed. An LO2/LH2 stage with a torus LO2 tank and 500 lbf pump fed engine is high on the list of propulsion technology. A.R.H.

N80-31456*# General Dynamics Corp., San Diego, Calif.
LOW-THRUST VEHICLES CONCEPT STUDIES
William J. Ketchum *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 73-96 (For primary document see N80-31449 22-20)
Avail: NTIS HC A15/MF A01 CSCL 21H

Low thrust chemical (hydrogen-oxygen) propulsion systems configured specifically for low acceleration orbit transfer of large space systems were studied in order to provide the required additional data to better compare new, low thrust chemical propulsion systems with other propulsion approaches such as advanced electric systems. Study results indicate that it is cost-effective and least risk to combine the low thrust OTV and stowed spacecraft in a single 65 K shuttle. Mission analysis indicates that there are 25 such missions, starting in 1987. Multiple shuttles (LSS in one, OTV in another) result in a 20% increase in LSS (SBR) diameter over single shuttle launches. Synthesis and optimization of the LSS characteristics and OTV capability resulted in determination of the optimum thrust-to-weight and thrust level. For the space based radar with radial truss arms (center thrust application), the optimum thrust-to-weight (maximum) is 0.1, giving a thrust of 2000 lb. For the annular truss (edge-on thrust application) the structure is not as sensitive, and thrust of 1000 lb appears optimum. For the geoplatform, optimum T/W is .15 (3000 lb thrust). The effects of LSS structure material, weight distribution, and unit area density were evaluated, as were the OTV engine thrust transient and number of burns. A.R.H.

N80-31457*# Aerojet Liquid Rocket Co., Sacramento, Calif.
LOW-THRUST CHEMICAL ROCKET ENGINE STUDY
Joseph A. Mellish *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 237-261 (For primary document see N80-31449 22-20)
(Contract NAS3-21940)
Avail: NTIS HC A15/MF A01 CSCL 21H

Parametric data and preliminary designs on liquid rocket engines for low thrust cargo orbit-transfer-vehicles are described and those items where technology is required to enhance the designs are identified. The results of film cooling studies to establish the upper chamber pressure limit are given. The study showed that regen cooling with RP-1 was not feasible over the entire thrust and chamber pressure ranges. The thermal data showed that the RP-1 bulk temperature exceeded the study coking temperature limit of 1010 R. Based upon the results presented, O2/H2 and O2/CH4 regen engine systems and O2/H2 film cooled engines were selected for further study in the system analysis. Six engine design concepts are examined. M.G.

N80-31458*# Martin Marietta Corp., Bethesda, Md.
PRIMARY PROPULSION/LARGE SPACE SYSTEM INTERACTIONS Progress Report, 20 Sep. 1979 - 20 Sep. 1980
Ralph H. Dergance *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul 1980 p 107-128 (For primary document see N80-31449 22-20)
(Contract NAS3-21955)
Avail: NTIS HC A15/MF A01 CSCL 21H

Three generic types of structural concepts and nonstructural surface densities were selected and combined to represent potential LSS applications. The design characteristics of various classes of large space systems that are impacted by primary propulsion thrust required to effect orbit transfer were identified. The effects of propulsion system thrust-to-mass ratio, thrust transients, and performance on the mass, area, and orbit transfer characteristics of large space systems were determined. A.R.H.

N80-31459*# Boeing Aerospace Co., Seattle, Wash.
AUXILIARY CONTROL OF LSS Progress Report, 28 Aug. 1979 - 27 Nov. 1980
William Smith *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 129-141 (For primary document see N80-31449 22-20)
(Contract NAS3-21952)
Avail: NTIS HC A15/MF A01 CSCL 21H

Seven classes of large space structures were identified and idealized into simple geometric shapes which could be easily modelled. Scaling laws were generated which allowed the seven ideal structures to be continuously scaled as to size and mass properties over their respective size ranges. Relevant sources of disturbances were determined and their effects on LSS were compared. These disturbances were applied over the range of scaling parameters to generate control force and torque requirements. Important auxiliary propulsion system (APS) characteristics were identified and an APS characteristic sensitivity matrix was established. A.R.H.

N80-31468*# Rockwell International Corp., Pittsburgh, Pa.
LOW-THRUST CHEMICAL PROPULSION
James M. Shoji *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 263-286 (For primary document see N80-31449 22-20)
Avail: NTIS HC A15/MF A01 CSCL 21H

Results from investigations leading to the definition of low thrust chemical engine concepts are described. From the thrust chamber cooling analyses, regenerative/radiation-cooled LO2/H2 thrust chambers offered the largest thrust and chamber pressure operational envelope primarily due to the superior cooling capability of hydrogen and its low critical pressure. Regenerative/radiation-cooled LO2/CH4 offered the next largest operational envelope. The maximum chamber pressure for film/radiation-cooling was significantly lower than for regenerative/radiation-cooling. As in regeneration-cooling, LO2/H2 thrust chambers achieved the highest maximum chamber pressure. LO2/CH4 film/radiation-cooling was found not feasible and LO2/RP-1 film/radiation-cooling was extremely limited. In the engine cycle/configuration evaluation, the engine cycle matrix was defined through the incorporation of the heat transfer results. Engine cycle limits were established with the fuel-cell power cycle achieving the highest chamber pressure; however, the fuel cell system weights were excessive The staged combustion cycle achieved the next highest chamber pressure but the preburner operational feasibility was in question M G

N80-31469*# Martin Marietta Corp., Bethesda, Md.
LOW-THRUST CHEMICAL ORBIT TO ORBIT PROPULSION SYSTEM PROPELLANT MANAGEMENT STUDY Progress Report, 14 Sep. 1979 - 14 Nov. 1980
Ralph H Dergance *In* NASA Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol Jul 1980 p 287-310 refs (For primary document see N80-31449 22-20)
(Contract NAS3-21954)
Avail NTIS HC A15/MF A01 CSCL 21H

Propellant requirements, tankage configurations, preferred propellant management techniques, propulsion systems weights, and technology deficiencies for low thrust expendable propulsion systems are examined A computer program was utilized which provided a complete propellant inventory (including boil-off for cryogenic cases), pressurant and propellant tank dimensions for a given ullage, pressurant requirements, insulation requirements, and miscellaneous masses The output also includes the masses of all tanks, the mass of the insulation, engines and other components, total wet system and burnout mass; system mass fraction, total impulse and burn time. M G

N80-31470*# Rockwell International Corp., Pittsburgh, Pa.
SOLAR ROCKET SYSTEM CONCEPT ANALYSIS Final Report
Jack A. Boddy *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol Jul 1980 p 311-336 (For primary document see N80-31449 22-20)
(Contract F04611-79-C-0007)
Avail NTIS HC A15/MF A01 CSCL 21H

The use of solar energy to heat propellant for application to Earth orbital/planetary propulsion systems is of interest because of its performance capabilities. The achievable specific impulse values are approximately double those delivered by a chemical rocket system, and the thrust is at least an order of magnitude greater than that produced by a mercury bombardment ion propulsion thruster. The primary advantage the solar heater thruster has over a mercury ion bombardment system is that its significantly higher thrust permits a marked reduction in mission trip time. The development of the space transportation system, offers the opportunity to utilize the full performance potential of the solar rocket. The requirements for transfer from low Earth orbit (LEO) to geosynchronous equatorial orbit (GEO) was examined as the return trip, GEO to LEO, both with and without payload. Payload weights considered ranged from 2000 to 100,000 pounds. The performance of the solar rocket was compared with that provided by LO2-LH2, N2O4-MMH, and mercury ion bombardment systems. A.R.H.

N80-33474*# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio
STATUS OF NICKEL-HYDROGEN CELL TECHNOLOGY
Don R. Warnock *In* NASA. Lewis Space Flight Center Synchronous Energy Technol. Sep. 1980 p 97-105 (For primary document see N80-33465 24-20)
Avail NTIS HC A07/MF A01 CSCL 10C

Nickel hydrogen cell technology has been developed which solves the problems of thermal management, oxygen management, electrolyte management, and electrical and mechanical design peculiar to this new type of battery. This technology was weight optimized for low orbit operation using computer modeling programs but is near optimum for other orbits. Cells ranging in capacity up to about 70 ampere-hours can be made from components of a single standard size and are available from two manufacturers. The knowledge gained is now being applied to the development of two extensions to the basic design: a second set of larger standard components that will cover the capacity range up to 150 ampere-hours; and the development of multicell common pressure vessel modules to reduce volume, cost and weight. A manufacturing technology program is planned to optimize the producibility of the cell design and reduce cost. The most important areas for further improvement are life and reliability which are governed by electrode and separator technology A R H

N80-33476*# Colorado State Univ Fort Collins Dept of Mechanical Engineering
BAFFLE APERTURE DESIGN STUDY OF HOLLOW CATHODE EQUIPPED ION THRUSTERS M.S. Thesis Technical Report, 1 Dec. 1979 - 1 Oct. 1980
John R Brophy, Jr and Paul J Wilbur Oct 1980 78 p refs
(Grant NGR-06-002-112)
(NASA-CR-165164) Avail NTIS HC A05/MF A01 CSCL 21C

A simple theoretical model which can be used as an aid in the design of the baffle aperture region of a hollow cathode equipped ion thruster was developed An analysis of the ion and electron currents in both the main and cathode discharge chambers is presented From this analysis a model of current flow through the aperture, which is required as an input to the design model, was developed This model was verified experimentally. The dominant force driving electrons through the aperture was the force due to the electrical potential gradient The diffusion process was modeled according to the Bolm diffusion theory. A number of simplifications were made to limit the amount of detailed plasma information required as input to the model to facilitate the use of the model in thruster design. This simplified model gave remarkably consistant results with experimental results obtained with a given thruster geometry over substantial changes in operating conditions The model was uncertain to about a factor of two for different thruster cathode region geometries. The design usefulness was limited by this factor of two uncertainty and by the accuracy to which the plasma parameters required as inputs to the model were specified T.M.

A80-13311 * # **8-cm Engineering Model Thruster technology - A review of recent developments.** W. S. Williamson, C. R. Dulgeroff, R. L. Williams (Hughes Research Laboratories, Malibu, Calif.), and J. R. Bayless (U.S. Defense Advanced Research Projects Agency, Washington, D.C.). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2103.* 9 p. 5 refs. Contract No. NAS3-21358.

Recent testing of the NASA Lewis Research Center/Hughes 8-cm Engineering Model Thruster (EMT) and Power Processing Unit has centered on two primary areas of investigation: integration of porous-tungsten dispenser-type cathode inserts into the thruster (replacing previous inserts of rolled-tantalum-foil design) and characterization of thruster operation with the new inserts. Characterization testing of the EMT and of the new cathodes has demonstrated acceptable thruster performance and cathode ignition parameters; the only perceived change in thuster performance has been that a small amount of cathode heater power is required to maintain nominal keeper voltages. Thermal modeling of the cathode structures has facilitated design revisions which reduce this power requirement. (Author)

A80-20962 * # **A model for predicting the wearout lifetime of the LeRC/Hughes 30-cm mercury ion thruster.** J. R. Beattie (Hughes Research Laboratories, Malibu, Calif.). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2079.* 16 p. 23 refs. Contract No. NAS3-21040.

An investigation of parameters that affect the erosion rates of 30-cm-diameter mercury-ion-thruster components is described. A sputter-erosion model is formulated in terms of the design, operational, and material characteristics of the thruster. The erosion model is applied to the screen electrode, which is assumed to be the life-limiting component of the 30-cm thruster, resulting in a model of wearout lifetime. Results of short-term erosion-rate tests are presented that illustrate the dependence of component wear rates on variables such as discharge voltage, accelerator-grid open-area fraction, ion energy, electrode material, and the partial pressure of facility residual gases such as nitrogen. Test results are compared with wearout rates predicted by the sputter-erosion model. (Author)

A80-23941 * # **Computation of three-dimensional viscous supersonic flow in inlets.** R. C. Buggeln, H. McDonald, J. P. Kreskovsky, and R. Levy (Scientific Research Associates, Inc., Glastonbury, Conn.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0194.* 12 p. 30 refs. Contract No. NAS3-21003.

A new approach has been developed for the computation of the three-dimensional viscous supersonic flow with embedded subsonic regions adjacent to solid boundaries and is applied to a mixed-compression supersonic inlet typical of current designs. The approach uses a reduced form of the three-dimensional Navier-Stokes equations so that the resultant equations can be treated as an initial boundary value problem and thus be solved by non-iterative forward marching in space. The numerical procedure utilizes an efficient consistently-split linearized block implicit technique to solve the finite difference analogues to the set of governing partial differential equations. (Author)

A80-46901 * # **Torquing and electrostatic deformation of the solar sail.** R. E. LaQuey (Maya Development Corp., San Diego, Calif.), S. E. DeForest, and M. Douglas. In: Space systems and their interactions with earth's space environment. (A80-46879 20-18) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 662-679. Contract No. NAS3-20119.

The impact of natural sources of electrical-mechanical oscillations induced by the environment on the solar sail system is evaluated. The study indicates that, to the level of accuracy (first order) of the analysis, none of the natural sources studied, which range from plasma wave interactions to E x B forces, will have a significant impact on the proposed solar sail design. The study is not intended as an exhaustive analysis, and further analysis, particularly in the area of artificially induced oscillations, is needed. (Author)

A80-48265 * # **Power processing technology for spacecraft primary ion propulsion.** J. J. Biess, L. Y. Inouye (TRW Defense and Space Systems Group, Redondo Beach, Calif.), and R. J. Frye (NASA, Lewis Research Center, Cleveland, Ohio). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 1. (A80-48165 21-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 782-787. 13 refs. Contracts No. NAS12-2183; No. NAS3-14383; No. NAS3-18924; No. NAS3-20403; No. NAS3-21372; No. NAS3-21746.

Advanced technologies developed in support of Ion Propulsion power processing, including the power circuitry portion of the Series L-C Resonant Inverter, Beam Supply, power components, packaging and heat pipe cooling of the 30 cm Ion Engine Power Processor are described. Both the transistorized and SCR versions of the Series L-C Resonant Inverter Beam Supply are discussed. A BIMOD Ion Thruster/Power Processor Prototype Assembly is undergoing environmental and life testing. These advanced technologies can be applied advantageously to other applications of future high power space power processing equipment. (Author)

A80-48356 * # **Design, performance and life cycle cost relationships for a 500kW space solar array.** P. W. Richardson, F. O. Miller, and M. N. White (PRC Systems Services Co., Huntsville, Ala.). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 2. (A80-48165 21-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 1396-1400. Contract No. NAS3-21926.

The effects on life cycle costs of a number of technology areas are examined for a LEO, 500kW space solar array. A baseline system conceptual design is developed and the life cycle costs estimated in detail. The baseline system requirements and design technologies are then varied and their relationships to life cycle costs quantified. For example, the thermal characteristics of the baseline design are determined by the array materials and masses. The thermal characteristics in turn determine configuration, performance and hence life cycle cost. (Author)

23 CHEMISTRY AND MATERIALS (GENERAL)

Includes biochemistry and organic chemistry.

A80-25900 * # **Investigation into the effect of plasma pretreatment on the adhesion of parylene to various substrates.** T. Riley, T. C. Mahuson, and K. Seibert (NASA, Lewis Research Center, Cleveland, Ohio). *Society for the Advancement of Material and Process Engineering, Seminar on Cleaning, Finishing and Coating Processes, Los Angeles, Calif., Feb. 5, 6, 1980, Paper.* 18 p. 13 refs.

An experimental effort has been undertaken to examine the effect of plasma pretreatment of various substrate materials coated with a polymer in the parylene family. This report describes the procedure and discusses initial data which indicate using plasmas of argon and oxygen to promote adhesion of parylene coatings upon many difficult-to-bond substrates. Substrates investigated were gold, nickel, kovar, teflon (FEP), kapton, silicon, tantalum, titanium, and tungsten. Without plasma treatment, 180 deg peel tests yield a few g/cm (oz/in) strengths. With dc plasma treatment in the deposition chamber, followed by coating, peel strengths are increased by one to two orders of magnitude. (Author)

A80-28894 * **Modeling and analysis of Power Processing Systems.** Y. Yu (TRW Defense and Space Systems Group, Redondo Beach, Calif.), F. C. Y. Lee (Virginia Polytechnic Institute and State University, Blacksburg, Va.), and J. Kolecki (NASA, Lewis Research Center, Cleveland, Ohio). In: PESC '79; Power Electronics Specialists Conference, San Diego, Calif., June 18-22, 1979, Record. (A80-28892 10-33) Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979, p. 11-24. 20 refs. Contract No. NAS3-19690.

The paper deals with a NASA-sponsored, computer-based program - Modeling and Analysis of Power Processing Systems (MAPPS). Three major MAPPS subprograms, Design Optimization, Control Design, and Performance Analysis are considered. The program makes it possible to reduce the design, analysis, and development time, and thus the cost, in achieving the required performance for power processing equipment and systems. V.T.

N80-33478*# Applied Medical Technology, Cleveland Heights, Ohio

TISSUE RESPONSE TO PERITONEAL IMPLANTS Final Report

George J. Picha Jun. 1980 73 p refs
(NASA Order C-33350-D)
(NASA-CR-159817) Avail. NTIS HC A04/MF A01 CSCL 06P

Peritoneal implants were fabricated from poly 2-OH, ethyl methacrylate (HEMA), polyetherurethane (polytetramethylene glycol 1000 MW, 1,4 methylene disocynate, and ethyl diamine), and untreated and sputter treated polytetrafluoroethylene (PTFE). The sputter treated PTFE implants were produced by an 8 cm diameter argon ion source. The treated samples consisted of ion beam sputter polished samples, sputter etched samples (to produce a microscopic surface cone texture) and surface pitted samples (produced by ion beam sputtering to result in 50 microns wide by 100 microns deep square pits). These materials were implanted in rats for periods ranging from 30 minutes to 14 days. The results were evaluated with regard to cell type and attachment kinetics onto the different materials. Scanning electron microscopy and histological sections were also evaluated. In general the smooth hydrophobic surfaces attracted less cells than the ion etched PTFE or the HEMA samples. The ion etching was observed to enhance cell attachment, multinucleated giant cell (MNGC) formation, cell to cell contact, and fibrous capsule formation. The cell responsed in the case of ion etched PTFE to an altered surface morphology. However, equally interesting was the similar attachment kinetics of HEMA verses the ion etched PTFE. However, HEMA resulted in a markedly different response with no MNGC's formation, minimal to no capsule formation, and sample coverage by a uniform cell layer. R.C.T.

24 COMPOSITE MATERIALS

Includes laminates.

N80-11142*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CORROSION RESISTANT THERMAL BARRIER COATING Patent Application
S. R. Levine, R. A. Miller, and P. E. Hodge, inventors (to NASA) Filed 31 Oct. 1979 8 p
(NASA-Case-LEW-13088-1; US-Patent-Appl-SN-089779) Avail: NTIS HC A02/MF A01 CSCL 11D

A thermal barrier coating system was developed to protect the surfaces of metal components, gas turbines, and other heat engine parts that are exposed to fuels contaminated with metallic impurities which are normally corrosive to previously known metallic coatings. The coating system includes a metal alloy bond coating, the alloy containing nickel, cobalt, iron, or a combination of these metals. The system also includes a corrosion resistant thermal barrier oxide coating containing at least one alkaline earth silicate. The preferred oxides are calcium silicate, barium silicate, magnesium silicate, or a combination of these silicates. NASA

N80-11143*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MICROMECHANICS OF INTRAPLY HYBRID COMPOSITES: ELASTIC AND THERMAL PROPERTIES
C. C. Chamis and J. H. Sinclair Washington 1979 19 p refs Presented at the Winter Ann. Meeting of the Am. Soc. of Mech. Engr., New York, 2-7 Dec. 1979
(NASA-TM-79253; E-164) Avail: NTIS HC A02/MF A01 CSCL 11D

Composite micromechanics are used to derive equations for predicting the elastic and thermal properties of unidirectional intraply hybrid composites. The results predicted using these equations are compared with those predicted using approximate equations based on the rule of mixtures, linear laminate theory, finite element analysis and limited experimental data. The comparisons for three different intraply hybrids indicate that all four methods predict approximately the same elastic properties and are in good agreement with measured data. The micromechanics equations and linear laminate theory predict about the same values for thermal expansion coefficients. The micromechanics equations predict through-the-thickness properties which are in good agreement with the finite element results. Author

N80-11144*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TENSILE AND FLEXURAL STRENGTH OF NON-GRAPHITIC SUPERHYBRID COMPOSITES: PREDICTIONS AND COMPARISONS
C. C. Chamis, J. H. Sinclair, and R. F. Lark 1979 27 p refs Presented at 11th Natl. Tech. Conf., Boston, Mass., 13-15 Nov. 1979; sponsored by Soc. for the Advancement of Material and Process Engr.
(NASA-TM-79276; E-203) Avail: NTIS HC A03/MF A01 CSCL 11D

Equations are presented and described which can be used to predict bounds on the tensile and flexural strengths of nongraphitic superhybrid (NGSH) composites. These equations are derived by taking into account the measured stress-strain behavior, the lamination residual stresses and the sequence of events leading to fracture. The required input for using these equations includes constituents, properties (elastic and strength), NGSH elastic properties, cure temperature, and ply stress influence coefficients. Results predicted by these equations are in reasonably good agreement with measured data for strength and for the apparent knees in the nonlinear stress-strain curve. The lower bound values are conservative compared to measured data. These equations are relatively simple and are suitable for use in the preliminary design and initial sizing of structural comonents made from NGSH composites. Author

N80-11145*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DYNAMIC RESPONSE OF DAMAGED ANGLEPLIED FIBER COMPOSITES
C. C. Chamis, J. H. Sinclair, and R. F. Lark 1979 17 p refs Presented at the Winter Ann. Meeting of the Am. Soc. of Mech. Engr., New York, 2-7 Dec. 1979
(NASA-TM-79281; E-182) Avail: NTIS HC A02/MF A01 CSCL 11D

The effects of low level damage induced by monotonic load, cyclic load and/or residual stresses on the vibration frequencies and damping factors of fiber composite angleplied laminates were investigated. Two different composite systems were studied - low modulus fiber and ultra high modulus fiber composites. The results obtained show that the frequencies and damping factors of angleplied laminates made from low modulus fiber composites are sensitve to low level damage while those made from ultra high modulus composites are not. Vibration tests may not be sufficiently sensitive to assess concentrated local damage in angleplied laminates. Dynamic response determined from low-velocity impact coupled with the Fast Fourier Transform and packaged in a minicomputer can be a convenient procedure for assessing low-level damage. A.R.H.

N80-12120*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MECHANICAL PROPERTY CHARACTERIZATION OF INTRAPLY HYBRID COMPOSITES
C. C. Chamis, R. F. Lark, and J. H. Sinclair 1979 26 p refs Presented at the Am. Soc. for Testing and Materials Symp., Dearborn, Mich., 2-3 Oct. 1979
(NASA-TM-79306; E-261) Avail: NTIS HC A03/MF A01 CSCL 11D

An investigation was conducted to characterize the mechanical properties of intraply hybrids made from graphite fiber/epoxy matrix (primary composites) hybridized with varying amounts of secondary composites made from S-glass or Kevlar 49 fibers. The tests were conducted using thin laminates having the same thickness. The specimens for these tests were instrumented with strain gages to determine stress-strain behavior. Significant results are included. R.C.T.

N80-13171*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPROVED FIBER RETENTION BY THE USE OF FILLERS IN GRAPHITE FIBER/RESIN MATRIX COMPOSITES
R. E. Gluyas and K. J. Bowles 1980 12 p refs Proposed for presentation at the 35th Ann. Conf. of the Reinforced Plastics/Composites Inst., New Orleans, 4-8 Feb. 1980; sponsored by Soc. of Plastics Ind.
(NASA-TM-79288; E-231) Avail: NTIS HC A02/MF A01 CSCL 11D

A variety of matrix fillers were tested for their ability to prevent loss of fiber from graphite fiber/PMR polyimide and graphite fiber/epoxy composites in a fire. The fillers tested included powders of boron, boron carbide lime glass, lead glass, and aluminum. Boron was the most effective and prevented any loss of graphite fiber during burning. Mechanical properties of composites containing boron filler were measured and compared to those of composites containing no filler. K.L.

N80-14196*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BURNING CHARACTERISTICS AND FIBER RETENTION OF GRAPHITE/RESIN MATRIX COMPOSITES
Kenneth J. Bowles 8 Feb. 1980 14 p refs Proposed for Presentation at the 35th Ann. Conf. of the Reinforced Plastics/Composites Inst., New Orleans, 4-8 Feb. 1980; sponsored by Soc. of Plastics Ind.
(NASA-TM-79314; E-271) Avail: NTIS HC A02/MF A01 CSCL 11D

Graphite fiber reinforced resin matrix composites were subjected to controlled burning conditions to determine their burning characteristics and fiber retention properties. Small samples were burned with a natural gas fired torch to study the effects of fiber orientation and structural flaws such as holes and slits that were machined into the laminates. Larger laminate samples were burned in a modified heat release rate calorimeter. Unidirectional epoxy/graphite and polyimide/graphite composites and boron powder filled samples of each of the two composite systems were burn tested. The composites were exposed to a thermal radiation of 5.3 Btu/sq ft-sec in air. Samples of each of the unfilled composite were decomposed anaerobically in the calorimeter. Weight loss data were recorded for burning and decomposition times up to thirty-five minutes. The effects of fiber orientation, flaws, and boron filler additives to the resins were evaluated. A high char forming polyimide resin was no more effective in retaining graphite fibers than a low char forming epoxy resin when burned in air. Boron powder additions to both the polyimide and the epoxy resins stabilized the chars and effectively controlled the fiber release. A.R.H.

N80-16102*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRACTURE MODES OF HIGH MODULUS GRAPHITE/EPOXY ANGLEPLIED LAMINATES SUBJECTED TO OFF-AXIS TENSILE LOADS
J. H. Sinclair 1980 22 p refs Presented at 35th Ann. Conf. of the Reinforced Plastics/Composites Inst., New Orleans, 4-8 Feb. 1980, sponsored by Soc. of Plastics Ind.
(NASA-TM-81405; E-319) Avail: NTIS HC A02/MF A01 CSCL 11D

Angelplied laminates of high modulus graphite fiber/epoxy were studied in several ply configurations at various tensile loading angles to the zero ply direction in order to determine the effects of ply orientations on tensile properties, fracture modes, and fracture surface characteristics of the various plies. It was found that fracture modes in the plies of angleplied laminates can be characterized by scanning electron microscope observation. The characteristics for a given fracture mode are similar to those for the same fracture mode in unidirectional specimens. However, no simple load angle range can be associated with a given fracture mode. Author

N80-16107*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PREDICTION OF FIBER COMPOSITE MECHANICAL BEHAVIOR MADE SIMPLE
C. C. Chamis 1980 26 p refs Presented at the 35th Ann. Conf. of the Reinforced Plastics/Composites Inst., New Orleans, 4-8 Feb. 1980; sponsored by the Soc. of Plastics Ind.
(NASA-TM-81404; E-331) Avail: NTIS HC A03/MF A01 CSCL 11D

The elastic properties and failure stresses of angleplied fiber composite laminates were determined using a pocket calculator. The procedure uses simple equations and appropriate graphs of elastic properties versus angle plies, and can handle all types of fiber composites including hybrids. The versatility and generality of the method is illustrated in several step-by-step numerical examples. A.R.H.

N80-18106*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
APPLICATION OF COMPOSITE MATERIALS TO TURBOFAN ENGINE FAN EXIT GUIDE VANES
G. T. Smith 1980 19 p refs Presented at 35th Ann. Conf. of the Reinforced Plastics/Composite Inst., New Orleans, 4-8 Feb. 1980; sponsored by Soc. of Plastics Industries
(NASA-TM-81432; E-356) Avail: NTIS HC A02/MF A01 CSCL 11D

A program was conducted by NASA with the JT9D engine manufacturer to develop a lightweight, cost effective, composite material fan exit guide vane design having satisfactory structural durability for commerical engine use. Based on the results of a previous company supported program, eight graphite/epoxy and graphite-glass/epoxy guide vane designs were evaluated and four were selected for fabrication and testing. Two commercial fabricators each fabricated 13 vanes. Fatigue tests were used to qualify the selected design configurations under nominally dry, 38 C (100 F) and fully wet and 60 C (140 F) environmental conditions. Cost estimates for a production rate of 1000 vanes per month ranged from 1.7 to 2.6 times the cost of an all aluminum vane. This cost is 50 to 80 percent less than the initial program target cost ratio which was 3 times the cost of an aluminum vane. Application to the JT9D commercial engine is projected to provide a weight savings of 236 N (53 lb) per engine. Author

N80-18107*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FIRE TEST METHOD FOR GRAPHITE FIBER REINFORCED PLASTICS
Kenneth J. Bowles 1980 13 p refs Presented at 5th Intern. Conf. on Fire Safety, Millbrae, Calif., 14-18 Jan. 1980
(NASA-TM-81436; E-360) Avail: NTIS HC A02/MF A01 CSCL 11D

A potential problem in the use of graphite fiber reinforced resin matrix composites is the dispersal of graphite fibers during accidential fires. Airborne, electrically conductive fibers originating from the burning composites could enter and cause shorting in electrical equipment located in surrounding areas. A test method for assessing the burning characteristics of graphite fiber reinforced composites and the effectiveness of the composites in retaining the graphite fibers has been developed. The method utilizes a modified rate of heat release apparatus. The equipment and the testing procedure are described. The application of the test method to the assessment of composite materials is illustrated for two resin matrix/graphite composite systems. A.R.H.

N80-20313*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DYNAMIC MODULUS AND DAMPING OF BORON, SILICON CARBIDE, AND ALUMINA FIBERS
J. A. DiCarlo and W. Williams [1980] 44 p refs Presented at the 4th Ann. Conf. on Composites and Advanced Mater., Cocoa Beach, Fla. 20-24 Jan. 1980; sponsored by the Am.
(NASA-TM-81422; E-345) Avail: NTIS HC A03/MF A01 CSCL 11D

The dynamic modulus and damping capacity for boron, silicon carbide, and silicon carbide coated boron fibers were measured from -190 to 800 C. The single fiber vibration test also allowed measurement of transverse thermal conductivity for the silicon carbide fibers. Temperature dependent damping capacity data for alumina fibers were calculated from axial damping results for alumina-aluminum composites. The dynamics fiber data indicate essentially elastic behavior for both the silicon carbide and alumina fibers. In contrast, the boron based fibers are strongly anelastic, displaying frequency dependent moduli and very high microstructural damping. Ths single fiber damping results were compared with composite damping data in order to investigate the practical and basic effects of employing the four fiber types as reinforcement for aluminum and titanium matrices. K.L.

N80-20314*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CALCULATION OF RESIDUAL PRINCIPAL STRESSES IN CVD BORON ON CARBON FILAMENTS
Donald R. Behrendt [1980] 15 p refs Prepared for the 4th Ann. Conf. on Composites and Advanced Mater., Cocoa Beach, Fla., 21-24 Jan. 1980; sponsored by the Am. Ceram. Soc.
(NASA-TM-81456; E-386) Avail: NTIS HC A02/MF A01 CSCL 11D

A three-dimensional finite element model of the chemical vapor deposition of boron on a carbon substrate (B/C) is developed. The model includes an expansion of the boron after deposition due to atomic rearrangement and includes creep of the boron and carbon. Curves are presented showing the variation of the principal residual stresses and the filament elongation with the parameters defining deposition strain and creep. The calculated results are compared with experimental axial residual stress and elongation measurements made on B/C filaments. For good agreement between calculated and experimental results, the deposited boron must continue to expand after deposition, and the build up of residual stresses must be limited by significant boron and carbon creep rates. K.L.

N80-21452*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PREDICTING THE TIME-TEMPERATURE DEPENDENT AXIAL FAILURE OF B/A1 COMPOSITES

James A. DiCarlo 1980 28 p refs Presented at Symp. on Failure Modes in Composites, Las Vegas, Nev., 25-26 Feb. 1980, sponsored by Metallurgical Soc. of the Am. Inst. of Mining, Metallurgical and Petroleum Engr.

(NASA-TM-81474; E-408) Avail: NTIS HC A03/MF A01 CSCL 11D

Experimental and theoretical studies were conducted in order to understand and predict the effects of time, temperature, and stress on the axial failure modes of boron fibers and B/A1 composites. Due to the anelastic nature of boron fiber deformation, it was possible to determine simple creep functions which can be employed to accurately describe creep and fracture stress of as-produced fibers. Analysis of damping and strength data for B/6061 A1 composites indicates that fiber creep effects of creep on fiber fracture are measurably reduced by the composite fabrication process. The creep function appropriate for fibers with B/Al composites was also determined. A fracture theory is presented for predicting the time-temperature dependence of the axial tensile strength for metal matrix composites in general and B/A1 composites in particular. Author

N80-23370*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ENGINE ENVIRONMENTAL EFFECTS ON COMPOSITE BEHAVIOR

C. C. Chamis and G. T. Smith 1980 20 p refs Presented at the 21st Struct., Structural Dyn. and Mater. Conf., Seattle, 12-14 May 1980; sponsored by AIAA, ASME, ASCE, and AHS (NASA-TM-81508; E-446) Avail: NTIS HC A02/MF A01 CSCL 11D

A series of programs were conducted to investigate and develop the application of composite materials to turbojet engines. A significant part of that effort was directed to establishing the impact resistance and defect growth chracteristics of composite materials over the wide range of environmental conditions found in commercial turbojet engine operations. Both analytical and empirical efforts were involved. The experimental programs and the analytical methodology development as well as an evaluation program for the use of composite materials as fan exit guide vanes are summarized. R.C.T.

N80-26389*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A SILICON-SLURRY/ALUMINIDE COATING Patent Application

D. L. Deadmore and S. G. Young, inventors (to NASA) Filed 20 Jun. 1980 11 p

(NASA-Case-LEW-13343-1; US-Patent-Appl-SN-161254) Avail: NTIS HC A02/MF A01 CSCL 11D

A low cost coating is disclosed which protects metallic base system substrates from high temperatures, high gas velocity oxidation, thermal fatigue and hot corrosion. The coating is particularly useful for protecting vanes and blades in aircraft and land based gas turbine engines. A lacquer slurry comprising cellulose nitrate containing high purity silicon powder is sprayed onto the superalloy substrates. The silicon layer is then aluminized to complete the coating. The Si-Al coating is less costly to produce than advanced aluminides and protects the substrate from oxidation and thermal fatigue for a much longer period of time than the conventional aluminide coatings. While more expensive Pt-Al coatings and physical vapor deposited MCrALY coatings on certain superalloys in high gas velocity oxidation and thermal fatigue. Also, the Si-Al coating increased the resistance of certain superalloys to hot corrosion. NASA

N80-27429*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

FEASIBILITY OF KEVLAR 49/PMR-15 POLYIMIDE FOR HIGH TEMPERATURE APPLICATIONS

Morgan P. Hanson 1980 16 p refs Proposed for presentation at the 12th Natl. SAMPE Tech. Conf., Seattle, 7-9 Oct. 1980 (NASA-TM-81560; E-521) Avail: NTIS HC A02/MF A01 CSCL 11D

Kevlar 49 aramid organic fiber reinforced PMR-15 polyimide laminates were characterized to determine the applicability of the material to high temperature aerospace structures. Kevlar 49/3501-6 epoxy laminates were fabricated and characterized for comparison with the Kevlar 49/PMR-15 polyimide material. Flexural strengths and moduli and interlaminar shear strengths were determined from 75 F to 600 F for the PMR-15 and from 75 F to 450 F for the Kevlar/3501-6 epoxy material. The effects of hydrothermal and long-term elevated temperature exposures on the flexural strengths and moduli and the interlaminar shear strengths were also studied. Author

N80-28444*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PROPERTIES OF PMR POLYIMIDE COMPOSITES MADE WITH IMPROVED HIGH STRENGTH GRAPHITE FIBERS

Raymond D. Vannucci 1980 18 p refs Proposed for presentation at 12th Natl. SAMPE Tech. Conf., Seattle, 7-9 Oct. 1980 (NASA-TM-81557; E-518) Avail: NTIS HC A02/MF A01 CSCL 11D

High strength, intermediate modulus graphite fibers were obtained from various commercial suppliers, and were used to fabricate PMR-15 and PMR-2 polyimide composites. The effects of the improved high strength graphite fibers on composite properties after exposure in air at 600 F were investigated. Two of the improved fibers were found to have an adverse effect on the long term performance of PMR composites. The influence of various factors such as fiber physical properties, surface morphology and chemical composition were also examined. R.C.T.

N80-29431*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

POTENTIAL RELEASE OF FIBERS FROM BURNING CARBON COMPOSITES

Vernon L. Bell Jul. 1980 52 p refs

(NASA-TM-80214) Avail: NTIS HC A04/MF A01 CSCL 11D

A comprehensive experimental carbon fiber source program was conducted to determine the potential for the release of conductive carbon fibers from burning composites. Laboratory testing determined the relative importance of several parameters influencing the amounts of single fibers released, while large-scale aviation jet fuel pool fires provided realistic confirmation of the laboratory data. The dimensions and size distributions of fire-released carbon fibers were determined, not only for those of concern in an electrical sense, but also for those of potential interest from a health and environmental standpoint. Fire plume and chemistry studies were performed with large pool fires to provide an experimental input into an analytical modelling of simulated aircraft crash fires. A study of a high voltage spark system resulted in a promising device for the detection, counting, and sizing of electrically conductive fibers, for both active and passive modes of operation. Author

N80-29433*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INFLUENCE OF EXCESS DIAMINE ON PROPERTIES OF PMR POLYIMIDE RESINS AND COMPOSITES

Francis I. Hurwitz 1980 15 p refs Proposed for presentation at 12th Natl. SAMPE Tech. Conf., Seattle, 7-9 Oct. 1980 (NASA-TM-81580; E-550) Avail: NTIS HC A02/MF A01 CSCL 11D

By varying the stoichiometry of the reactants in the preparation of PMR polyimide resin, changes occur in molecular weight distribution which influence the rheological properties and thus the processabilibty of the resin, as well as the mechanical properties of the composite. The influence of 1-10 percent molar excess MDA on the molecular weight distribution and rheological properties of an imidized PMR system were exposed Molecular weight distribution is characterized by gel permeation chromatography of the imidized molding compound. shear viscosity is related to changes in average molecular weight The thermo-oxidative stability at 600 F, glass transition temperature, flexural and interlaminar shear properties of PMR polyimide/Celion 6000 graphite fiber composites are compared as a function of the percent excess MDA in the monomer reactant mixture.

A.R.H.

N80-33482* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

METHOD OF MAKING BEARING MATERIAL Patent

Harold E Sliney, inventor (to NASA) Issued 29 Jul. 1980 7 p Filed 31 Jan 1977 Supersedes N77-32249 (15 - 23, p 3050) Division of abandoned US Patent Appl SN-616528, filed 25 Sep 1975, which is a division of US Patent Appl. SN-513611, filed 10 Oct 1974

(NASA Case-LEW-11930-3. US-Patent-4,214,905.
US-Patent-Appl-SN-764245. US-Patent-Class-75-200;
US-Patent-Class-75-222. US-Patent-Appl-SN-616528.
US-Patent-Appl-SN-513611) Avail US Patent and Trademark Office CSCL 11D

A composite material is described which will provide low friction surfaces for materials in rolling or sliding contact and is self lubricating and oxidation resistant up to and in excess of about 930 C The composite is comprised of a metal component which lends strength and elasticity to the structure, a fluoride salt component which provides lubrication and, lastly, a glass component which not only provides oxidation protection to the metal but may also enhance the lubrication qualities of the composite

Official Gazette of the U S Patent and Trademark Office

A80-10036 * # **Fatigue behavior of SiC reinforced titanium composites.** R. T. Bhatt and H. H. Grimes (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Testing and Materials, Symposium on Fatigue of Fibrous Composite Materials, San Francisco, Calif., May 22, 23, 1979, Paper.* 18 p. 12 refs.

The low cycle axial fatigue properties of 25 and 44 fiber volume percent SiC/Ti(6Al-4V) composites were measured at room temperature and at 650 C. At room temperature, the S-N curves for the composites showed no anticipated improvement over bulk matrix behavior. Although axial and transverse tensile strength results suggest a degradation in SiC fiber strength during composite fabrication, it appears that the poor fatigue life of the composites was caused by a reduced fatigue resistance of the reinforced Ti(6Al-4V) matrix. Microstructural studies indicate that the reduced matrix behavior was due, in part, to the presence of flawed and fractured fibers created near the specimen surfaces by preparation techniques. Another possible contributing factor is the large residual tensile stresses that can exist in fiber-reinforced matrices. These effects, as well as the effects of fatigue testing at high temperature, are discussed. (Author)

A80-20954 * # **Mechanical property characterization of intraply hybrid composites.** C. C. Chamis, R. F. Lark, and J. H. Sinclair (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Testing and Materials, Symposium, Dearborn, Mich., Oct. 2, 3, 1979, Paper.* 24 p. 5 refs.

An investigation of the mechanical properties of intraply hybrids made from graphite fiber/epoxy matrix hybridized with secondary S-glass or Kevlar 49 fiber composites is presented. The specimen stress-strain behavior was determined, showing that mechanical properties of intraply hybrid composites can be measured with available methods such as the ten-degree off-axis test for intralaminar shear, and conventional tests for tensile, flexure, and Izod impact properties. The results also showed that combinations of high modulus graphite/S-glass/epoxy matrix composites exist which yield intraply hybrid laminates with the best 'balanced' properties, and that the translation efficiency of mechanical properties from the constituent composites to intraply hybrids may be assessed with a simple equation. A.T.

A80-27982 * # **Dynamic response of damaged angleplied fiber composites.** C. C. Chamis, J. H. Sinclair, and R. F. Lark (NASA, Lewis Research Center, Cleveland, Ohio). In: Modern developments in composite materials and structures; Proceedings of the Winter Annual Meeting, New York, N.Y., December 2-7, 1979. (A80-27979 10-39) New York, American Society of Mechanical Engineers, 1979, p. 31-51.

An investigation was conducted to determine the effects of low level damage induced by monotonic load, cyclic load and/or residual stresses on the vibration frequencies and damping factors of fiber composite angleplied laminates. Two different composite systems were studied - low modulus fiber and ultra high modulus fiber composites. The results obtained showed that the frequencies and damping factors of angleplied laminates made from low modulus fiber composites are sensitive to low level damage while those made from ultra high modulus composites are not. Also, vibration tests may not be sufficiently sensitive to assess concentrated local damage in angleplied laminates. And furthermore, dynamic response determined from low-velocity impact coupled with the Fast Fourier Transform and packaged in a minicomputer can be a convenient procedure for assessing low-level damage in fiber composite angleplied laminates. (Author)

A80-27994 * # **Micromechanics of intraply hybrid composites: Elastic and thermal properties.** C. C. Chamis and J. H. Sinclair (NASA, Lewis Research Center, Cleveland, Ohio). In: Modern developments in composite materials and structures; Proceedings of the Winter Annual Meeting, New York, N.Y., December 2-7, 1979. (A80-27979 10-39) New York, American Society of Mechanical Engineers, 1979, p. 253-267.

Composite micromechanics are used to derive equations for predicting the elastic and thermal properties of unidirectional intraply hybrid composites. The results predicted using these equations are compared with those predicted using approximate equations based on the rule of mixtures, linear laminate theory, finite element analysis and limited experimental data. The comparisons for three different intraply hybrids indicate that all four methods predict approximately the same elastic properties and are in good agreement with measured data. The micromechanics equations and linear laminate theory predict about the same values for thermal expansion coefficients. The micromechanics equations predict through-the-thickness properties which are in good agreement with the finite element results. (Author)

A80-31169 * # **Fire test method for graphite fiber reinforced plastics.** K. J. Bowles (NASA, Lewis Research Center, Cleveland, Ohio). *International Conference on Fire Safety, 5th, Millbrae, Calif., Jan. 14-18, 1980, Paper.* 11 p. 12 refs.

A potential problem in the use of graphite fiber reinforced resin matrix composites is the dispersal of graphite fibers during accidental fires. Airborne, electrically conductive fibers originating from the burning composites could enter and cause shorting in electrical equipment located in surrounding areas. A test method for assessing the burning characteristics of graphite fiber reinforced composites and the effectiveness of the composites in retaining the graphite fibers has been developed. The method utilizes a modified Ohio State University Rate of Heat Release apparatus. The equipment and the testing procedure are described. The application of the test method to the assessment of composite materials is illustrated for two resin matrix/graphite composite systems. (Author)

A80-32062 * # **Burning characteristics and fiber retention of graphite/resin matrix composites.** K. J. Bowles (NASA, Lewis Research Center, Cleveland, Ohio). In: Rising to the challenge of the

'80s; Annual Conference and Exhibit, 35th, New Orleans, La., February 4-8, 1980, Preprints. (A80-32058 12-24) New York, Society of the Plastics Industry, Inc., 1980, p. 11-B 1 to 11-B 5. 8 refs.

Graphite fiber reinforced resin matrix composites were subjected to controlled burning conditions to determine their burning characteristics and fiber retention properties. Two types of burning equipment were used. Small samples were burned with a natural gas fired torch to study the effects of fiber orientation and structural flaws such as holes and slits that were machined into the laminates. Larger laminate samples were burned in a Heat Release Rate Calorimeter. Unidirectional epoxy/graphite and polyimide/graphite composites and boron powder filled samples of each of the two composite systems were burn tested and exposed to a thermal radiation. The effects of fiber orientation, flaws, and boron filler additives to the resins were evaluated. A high char forming polyimide resin was no more effective in retaining graphite fibers than a low char forming epoxy resin when burning in air. (Author)

A80-32066 * # **Improved fiber retention by the use of fillers in graphite fiber/resin matrix composites.** R. E. Gluyas and K. J. Bowles (NASA, Lewis Research Center, Cleveland, Ohio). In: Rising to the challenge of the '80s; Annual Conference and Exhibit, 35th, New Orleans, La., February 4-8, 1980, Preprints. (A80-32058 12-24) New York, Society of the Plastics Industry, Inc., 1980, p. 11-F 1 to 11-F 4. 5 refs.

A potential problem in the use of graphite fiber reinforced resin matrix composites is the dispersal of graphite fiber during accidental fires. Airborne electrically conductive fibers originating from burning composites could enter and cause shorting in electrical equipment located in surrounding areas. A variety of matrix fillers have been tested for their ability to prevent loss of fiber from graphite fiber/PMR polyimide and graphite fiber/epoxy composites in a fire. The fillers tested included powders of boron, boron carbide (B4C), lime glass, lead glass, and aluminum. Of these fillers, boron was the most effective and prevented any loss of graphite fiber during burning. Mechanical properties of composites containing boron filler were measured and compared to those of composite containing no filler. (Author)

A80-32069 * # **Fracture modes of high modulus graphite/epoxy angleplied laminates subjected to off-axis tensile loads.** J. H. Sinclair (NASA, Lewis Research Center, Cleveland, Ohio). In: Rising to the challenge of the '80s; Annual Conference and Exhibit, 35th, New Orleans, La., February 4-8, 1980, Preprints. (A80-32058 12-24) New York, Society of the Plastics Industry, Inc., 1980, p. 12-C 1 to 12-C 8. 6 refs.

Angleplied laminates of high modulus graphite fiber/epoxy were examined in several ply configurations at various tensile loading angles to the zero ply direction to determine the effects of ply orientations on tensile properties, fracture modes, and fracture surface characteristics of the various plies. Experimental results consist of stress-strain data, selected plots, fracture stresses and strains, and scanning electron microscope (SEM) photographs of fracture surfaces. It was found that the stress-strain curves were linear to fracture, and that although fracture surface characteristics for a given fracture mode are similar to those for the same fracture mode in uniaxial specimens, no simple load angle range can be associated with a given fracture mode. It was also concluded that SEM results must be supplemented with ply stress calculations in order to identify ranges of fracture modes occurring as a function of ply orientation with respect to the load direction. J.P.B.

A80-32632 * **Preparation of cast aluminum alloy-mica particle composites.** Mr. Deonath (Banaras Hindu University, Varanasi, India), R. T. Bhat (NASA, Lewis Research Center, Cleveland, Ohio), and P. K. Rohatgi (Indian Institute of Science, Bangalore, India). *Journal of Materials Science,* vol. 15, May 1980, p. 1241-1251. 17 refs.

A method for making aluminum-mica particle composites is presented in which mica particles are stirred in molten aluminum alloys followed by casting in permanent molds. Magnesium is added either as an alloying element or in the form of pieces to the surface of the alloy melts to disperse up to 3 wt% mica powders in the melts and to obtain high recoveries of mica in the castings. The mechanical properties of the aluminum alloy-mica composite decrease with increasing mica content; however, even at 2.2% it has a tensile strength of 14.22 kg/sq mm with 1.1% elongation, a compression strength of 42.61 kg/sq mm, and an impact strength of 0.30 kgm/sq cm. Cryogenic and self-lubricating bearing are mentioned applications. L.M.

A80-34764 * **A review of issues and strategies in nondestructive evaluation of fiber reinforced structural composites.** A. Vary (NASA, Lewis Research Center, Materials and Structures Div., Cleveland, Ohio). In: New horizons - Materials and processes for the eighties; Proceedings of the Eleventh National Conference, Boston, Mass., November 13-15, 1979. (A80-34751 14-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1979, p. 166-177. 12 refs.

The need for advanced nondestructive evaluation (NDE) techniques for quantitative assessment of the mechanical strength and integrity of fiber composites during manufacture and service and following repair operations is stressed. The discussion covers problems and different approaches in regard to acceptance criteria, calibration standards, and methods for NDE of composites in strength critical applications. Finally, it is concluded that acousto-ultrasonic techniques provide the 'methods of choice' in this area. M.E.P.

A80-34789 * **High char imide-modified epoxy matrix resins.** T. T. Serafini, P. Delvigs, and R. D. Vannucci (NASA, Lewis Research Center, Cleveland, Ohio). In: New horizons - Materials and processes for the eighties; Proceedings of the Eleventh National Conference, Boston, Mass., November 13-15, 1979. (A80-34751 14-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1979, p. 564-573.

Studies were performed to synthesize a novel class of bis (imide-amine) curing agents for epoxy matrix resins. Glass transition temperatures and char yield data of an epoxy cured with various bis (imide-amines) are presented. The room temperature and 350 F mechanical properties, and char yields of unidirectional graphite fiber laminates prepared with conventional epoxy and imide-modified epoxy resins are presented. (Author)

A80-35494 * # **Predicting the time-temperature dependent axial failure of B/Al composites.** J. A. DiCarlo (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Society of AIME, Symposium on Fracture Modes in Metal Metrix Composites, Las Vegas, Nev., Feb. 25-28, 1980, Paper.* 26 p. 21 refs.

Theoretical and experimental studies are reviewed whose objective was to gain insight into and predict the effects of time, temperature, and stress on the axial failure modes of boron fibers and B/Al composites. Owing to the inelastic nature of boron fiber deformation, it proved possible to develop simple creep functions which can be used to describe accurately the creep and fracture stress of as-produced fibers. Analysis of damping and stress data for B/6061 Al composites indicates that fiber creep and the effects of creep of fiber fracture are measurably reduced by the composite fabrication process. V.P.

A80-44236 * # **Dynamic modulus and damping of boron, silicon carbide, and alumina fibers.** J. A. DiCarlo (NASA, Lewis Research Center, Cleveland, Ohio) and W. Williams (Lincoln University, Lincoln University, Pa.). *American Ceramic Society, Annual Conference on Composites and Advanced Materials, 4th, Cocoa*

Beach, Fla., Jan. 21-24, 1980, Paper. 42 p. 19 refs.

The dynamic modulus and damping capacity for boron, silicon carbide, and silicon carbide-coated boron fibers were measured from -190 to 800 C. The single fiber vibration test also allowed measurement of transverse thermal conductivity for the silicon carbide fibers. Temperature-dependent damping capacity data for alumina fibers were calculated from axial damping results for alumina-aluminum composites. The dynamic fiber data indicate essentially elastic behavior for both the silicon carbide and alumina fibers. In contrast, the boron-based fibers are strongly anelastic, displaying frequency-dependent moduli and very high microstructural damping. The single fiber damping results were compared with composite damping data in order to investigate the practical and basic effects of employing the four fiber types as reinforcement for aluminum and titanium matrices. (Author)

A80-44237 * # **Calculation of residual principal stresses in CVD boron on carbon filaments.** D. R. Behrendt (NASA, Lewis Research Center, Cleveland, Ohio). *American Ceramic Society, Annual Conference on Composites and Advanced Materials, 4th, Cocoa Beach, Fla., Jan. 21-24, 1980, Paper.* 13 p. 5 refs.

A three-dimensional finite element model of the chemical vapor deposition (CVD) of boron on a carbon substrate (B/C) is developed. The model includes an expansion of the boron after deposition due to atomic rearrangement and includes creep of the boron and carbon. Curves are presented to show how the principal residual stresses and the filament elongation vary as the parameters defining deposition strain and creep are varied. The calculated results are compared with experimental axial residual stress and elongation measurements made on B/C filaments. This comparison requires that for good agreement between calculated and experimental results, the deposited boron must continue to expand after deposition, and that the build-up of residual stresses is limited by significant boron and carbon creep rates. (Author)

N80-10318*# Avco Systems Div., Wilmington, Mass.
IMPROVING THE STRESS RUPTURE AND CREEP OF SILICON NITRIDE Final Report
T Vasilos, R M Cannon, Jr., and B. J. Wuensch 30 Mar. 1979 68 p refs
(Contract NAS3-20088)
(NASA-CR-159585) Avail: NTIS HC A04/MF A01 CSCL 11D

Yttria-stabilized zirconium oxide (Zyttrite) additions to purified silicon nitride markedly improved the high temperature strength, stress rupture and creep properties of hot pressed samples. Room temperature bend strengths, however, of four (4) compositions evaluated were each about one-third lower than the NC-132 silicon nitride composition. This difference decreased with increasing temperature until at 1200 C, there was reasonable equivalence between most of the zyttrite containing compositions and NC-132 in terms of short time bend strength measurements. At 1370 C, the 10 and 20 wt. % containing zyttrite compositions showed bend strengths as much as double the NC-132 material. Bend stress rupture results for 10 and 20 wt. % zyttrite containing compositions showed a strong stress sensitivity at the 176 MN/sq m (40 Kpsi) level above 1200 C. Creep in bending measurements showed that at 1370 C, zyttrite containing compositions exhibited creep rates that were about two orders of magnitude lower than NC-132 material samples. All compositions appeared to follow deformation kinetics related to a visco-elastic mechanism, i.e., glassy phase diffusional creep or grain boundary sliding. A.R.H.

N80-10319*# United Technologies Research Center, East Hartford, Conn.
DEVELOPMENT OF SILICON NITRIDE OF IMPROVED TOUGHNESS Final Report
J. J. Brennan 2 Oct. 1979 111 p refs
(Contract NAS3-21375)
(NASA-CR-159676; R79-914364-12) Avail: NTIS HC A06/MF A01 CSCL 11D

The application of reaction sintered Si2N4 energy absorbing surface layers to hot-pressed Si3N4 was investigated. The surface layer was formed by in-place nitridation of silicon powder. It was found that reaction sintered Si3N4 layers of 1 mm thickness, fabricated from either -100, +200, -200, or -325 mesh Si powder and nitrided in 96% N2/4% H2 so that approximately 20-25 vol % unnitrided Si remained in the layer, resulted in a sevenfold increase in ballistic impact resistance of a 0.64 cm thick hot-pressed SI3N4 substrate from RT 1370 C. Both NC-132 SI3N4, with MgO additive, and NCX-34 Si3N4, with Y2O3 additive, were evaluated as substrate material. The finer grain size -200 and -325 mesh nitrided Si layers were for their in N2/H2 mixtures, rather than pure N2, resulted in a microstructure that did not substantially degrade the strength of the hot pressed Si3N4 substrate. Thermal cycling tests on the RSSN/HPSN combinations from 200 C to 1370 C for 75 cycles in air did not degrade the impact resistance nor the interfacial bonding, although a large amount of internal silica formation occurred within the RSSN layer. Mach 0.8, 5 hr, hot gas erosion tests showed no surface recession of RSSN layers at 1200 C and slight surface recession at 1370 C. M.M.M.

N80-12118*# TRW Equipment Labs., Cleveland, Ohio.
SECOND GENERATION PMR POLYIMIDE/FIBER COMPOSITES
P. J. Cavano 26 Oct. 1979 144 p refs
(Contract NAS3-21349)
(NASA-CR-159666; ER-7989F) Avail: NTIS HC A07/MF A01 CSCL 11D

A second generation polymerization monomeric reactants (PMR) polyimdes matrix system (PMR 2) was characterized in both neat resin and composite form with two different graphite fiber reinforcements. Three different formulated molecular weight levels of laboratory prepared PMR 2 were examined, in addition to a purchased experimental fully formulated PMR 2 precurser solution. Isothermal aging of graphite fibers, neat resin samples and composite specimens in air at 316 C were investigated. Humidity exposures at 65 C and 97 percent relative humidity were conducted for both neat resin and composites for eight day periods. Anaerobic char of neat resin and fire testing of composites were conducted with PMR 15, PMR 2, and an epoxy system. Composites were fire tested on a burner rig developed for this program. Results indicate that neat PMR 2 resins exhibit excellent isothermal resistance and that PMR 2 composite properties appear to be influenced by the thermo-oxidative stability of the reinforcing fiber. R.C.T.

N80-22407*# Westinghouse Research and Development Center, Pittsburgh, Pa.
SILICONE MODIFIED RESINS FOR GRAPHITE FIBER LAMINATES Final Report
L. W. Frost and G. M. Bower 28 Sep. 1979 75 p refs
(Contract NAS3-21373)
(NASA-CR-159750; FR-79-9b7-SICOP-R1) Avail: NTIS HC A04/MF A01 CSCL 11D

The development of silicon modified resins for graphite fiber laminates which will prevent the dispersal of graphite fibers when the composites are burned is discussed. Eighty-five silicone modified resins were synthesized and evaluated including unsaturated polyesters, thermosetting methacrylates, epoxies, polyimides, and phenolics. Neat resins were judged in terms of Si content, homogeneity, hardness, Char formation, and thermal stability. Char formation was estimated by thermogravimetry to 1,000 C in air and in N2. Thermal stability was evaluated by isothermal weight loss measurements for 200 hrs in air at three temperatures. Four silicone modified epoxies were selected for evaluation in unidirectional filament wound graphite laminates. Neat samples of these resins had 1,000 C char residues of 25 to 50%. The highest flexural values measured for the laminates were a strength of 140 kpsi and a modulus of 10 Mpsi. The highest interlaminar shear strength was 5.3 kpsi. M.G.

N80-25382*# Hamilton Standard, Windsor Locks, Conn.
DIFFUSION BONDED BORON/ALUMINUM SPAR-SHELL

FAN BLADE Final Report, Jun. 1977 - May 1978
C. E. K. Carlson, J. L. Cutler, W. J. Fisher, and J. V. W. Memmott
Jun. 1980 114 p refs
(Contract NAS3-20407)
(NASA-CR-159571; HSER-7968) Avail: NTIS
HC A06/MF A01 CSCL 11D

Design and process development tasks intended to demonstrate composite blade application in large high by-pass ratio turbofan engines are described. Studies on a 3.0 aspect radio space and shell construction fan blade indicate a potential weight savings for a first stage fan rotor of 39% when a hollow titanium spar is employed. An alternate design which featured substantial blade internal volume filled with titanium honeycomb inserts achieved a 14% potential weight savings over the B/M rotor system. This second configuration requires a smaller development effort and entails less risk to translate a design into a successful product. The feasibility of metal joining large subsonic spar and shell fan blades was demonstrated. Initial aluminum alloy screening indicates a distinct preference for AA6061 aluminum alloy for use as a joint material. The simulated airfoil pressings established the necessity of rigid air surfaces when joining materials of different compressive rigidities. The two aluminum alloy matrix choices both were successfully formed into blade shells. A.R.H.

N80-25383*# Lehigh Univ., Bethlehem, Pa. Inst. of Fracture and Solid Mechanics.
SUDDEN STRETCHING OF A FOUR LAYERED COMPOSITE PLATE Interim Report
G. C. Sih and E. P. Chen Mar. 1980 42 p refs
(Grant NsG-3197)
(NASA-CR-159870; IFSM-80-102) Avail: NTIS
HC A03/MF A01 CSCL 11D

An approximate theory of laminated plates is developed by assuming that the extensioral and thickness mode of vibration are coupled. The mixed boundary value crack problem of a four layered composite plate is solved. Dynamic stress intensity factors for a crack subjected to suddenly applied stress are found to vary as a function of time and depend on the material properties of the laminate. Stress intensification in the region near the crack front can be reduced by having the shear modulus of the inner layers to be larger than that of the outer layers. Author

N80-25384*# Lehigh Univ., Bethlehem, Pa. Inst. of Fracture and Solid Mechanics.
SUDDEN BENDING OF CRACKED LAMINATES Interim Report
G. C. Sih and E. P. Chen Feb. 1980 53 p refs
(Contract NsG-3197)
(NASA-CR-159860; IFSM-80-103) Avail: NTIS
HC A04/MF A01 CSCL 11D

A dynamic approximate laminated plate theory is developed with emphasis placed on obtaining effective solution for the crack configuration where the 1/square root of r stress singularity and the condition of plane strain are preserved. The radial distance r is measured from the crack edge. The results obtained show that the crack moment intensity tends to decrease as the crack length to laminate plate thickness is increased. Hence, a laminated plate has the desirable feature of stabilizing a through crack as it increases its length at constant load. Also, the level of the average load intensity transmitted to a through crack can be reduced by making the inner layers to be stiffer than the outer layers. The present theory, although approximate, is useful for analyzing laminate failure to crack propagation under dynamic load conditions. Author

N80-29430*# Fiber Materials, Inc., Biddeford, Maine.
FABRICATION AND EVALUATION OF LOW FIBER CONTENT ALUMINA FIBER/ALUMINUM COMPOSITES Final Report
J. E. Hack and G. C. Strempek 18 Jun. 1980 72 p refs
(Contract NAS3-21371)
(NASA-CR-159517; AMDL-0001) Avail: NTIS
HC A04/MF A01 CSCL 11D

The mechanical fabrication of low volume percent fiber, polycrystalline alumina fiber reinforced aluminum composites was accomplished. Wire preform material was prepared by liquid-metal infiltration of alumina fiber bundles. The wires were subsequently encapsulated with aluminum foil and fabricated into bulk composite material by hot-drawing. Extensive mechanical, thermal and chemical testing was conducted on preform and bulk material to develop a process and material data bas-. In addition, a preliminary investigation of mechanical forming of bulk alumina fiber reinforced aluminum composite material was conducted. Author

N80-29432*# George Washington Univ., Washington, D. C. School of Engineering and Applied Science
STATISTICAL ASPECTS OF CARBON FIBER RISK ASSESSMENT MODELING
Donald Gross, Douglas R. Miller, and Richard M. Soland Jul. 1980 127 p refs
(Contract NsG-1556)
(NASA-CR-159318) Avail: NTIS HC A07/MF A01 CSCL 11D

The probabilistic and statistical aspects of the carbon fiber risk assessment modeling of fire accidents involving commercial aircraft are examined. Three major sources of uncertainty in the modeling effort are identified. These are: (1) imprecise knowledge in establishing the model; (2) parameter estimation; and (3) Monte Carlo sampling error. All three sources of uncertainty are treated and statistical procedures are utilized and/or developed to control them wherever possible. A.R.H.

A80-32063 * # **Fiber release characteristics of graphite hybrid composites.** J. Henshaw (Avco Corp., Lowell, Mass.). In: Rising to the challenge of the '80s; Annual Conference and Exhibit, 35th, New Orleans, La., February 4-8, 1980, Preprints. (A80-32058 12-24) New York, Society of the Plastics Industry, Inc., 1980, p. 11-C 1 to 11-C 8. Contract No. NAS3-21385.

The paper considers different material concepts that can be fabricated of hybridized composites which demonstrate improved graphite fiber retention capability in a severe fire without significant reduction to the composite properties. More than 30 panels were fabricated for mechanical and fire tests, the details and results of which are presented. Methods of composite hybridization investigated included the addition of oxidation resistant fillers to the resin, mechanically interlocking the graphite fibers by the use of woven fabrics, and the addition of glass fibers and glass additives designed to melt and fuse the graphite fibers together. It is concluded that a woven fabric with a serving of glass around each graphite tow is by far the superior of those evaluated: not only is there a coalescing effect in each graphite layer, but there is also a definite adhesion of each layer to its neighbor. J.P.B.

A80-32064 * # **Hybrid composites that retain graphite fibers on burning.** E. E. House (Boeing Aerospace Co., Seattle, Wash.). In: Rising to the challenge of the '80s; Annual Conference and Exhibit, 35th, New Orleans, La., February 4-8, 1980, Preprints. (A80-32058 12-24) New York, Society of the Plastics Industry, Inc., 1980, p. 11-D 1 to 11-D 8. Contract No. NAS3-21383.

A laboratory scale program was conducted to determine fiber release tendencies of graphite reinforced/resinous matrix composites currently used or projected for use in civil aircraft. In the event of an aircraft crash and burn situation, there is concern that graphite fibers will be released from the composites once the resin matrix is thermally decomposed. Hybridizing concepts aimed at preventing fiber release on burning were postulated and their effectiveness evaluated under fire, impact, and air flow during an aircraft crash. (Author)

25 INORGANIC AND PHYSICAL CHEMISTRY

Includes chemical analysis, e.g., chromatography; combustion theory; electrochemistry; and photochemistry.

For related information see also *77 Thermodynamics and Statistical Physics*.

N80-24386*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN INTERACTIVE MODULAR DESIGN FOR COMPUTERIZED PHOTOMETRY IN SPECTROCHEMICAL ANALYSIS
Virginia L. Bair 1980 17 p Presented at the Pittsburgh Conf. on Anal. Chem. and Appl. Spectry., Atlantic City, 10-14 Mar. 1980; cosponsored by the Soc. for Anal. Chemists of Pittsburgh and the Spectry. Soc. of Pittsburgh
(NASA-TM-81521; E-465) Avail: NTIS HC A02/MF A01 CSCL 07D

A general functional description of totally automatic photometry of emission spectra is not available for an operating environment in which the sample compositions and analysis procedures are low-volume and non-routine. The advantages of using an interactive approach to computer control in such an operating environment are demonstrated. This approach includes modular subroutines selected at multiple-option, menu-style decision points. This style of programming is used to trace elemental determinations, including the automated reading of spectrographic plates produced by a 3.4 m Ebert mount spectrograph using a dc-arc in an argon atmosphere. The simplified control logic and modular subroutine approach facilitates innovative research and program development, yet is easily adapted to routine tasks. Operator confidence and control are increased by the built-in options including degree of automation, amount of intermediate data printed out, amount of user prompting, and multidirectional decision points. A.R.H.

A80-10041 * # **The chemistry of sodium chloride involvement in processes related to hot corrosion.** C. A. Stearns, F. J. Kohl, and G. C. Fryburg (NASA, Lewis Research Center, Cleveland, Ohio). *U.S. Department of Energy, and Electric Power Research Institute, Conference on Advanced Materials for Alternate Fuel Capable Directly Fired Heat Engines, Castine, Me., July 30-Aug. 3, 1979, Paper.* 30 p. 47 refs.

Sodium chloride is one of the primary contaminants that enter gas turbine engines and contribute, either directly or indirectly, to the hot corrosion degradation of hot-gas-path components. The paper surveys the results of laboratory experiments along with thermodynamic and mass transport calculations, intended for elucidating the behavior of sodium chloride in combustion environments. It is shown that besides being a source of sodium for the formation of corrosive liquid Na_2SO_4, the NaCl itself contributes in other indirect ways to the material degradation associated with the high-temperature environmental attack. In addition, the experimental results lend credence to the conceptual scheme presented schematically (behavior of NaCl in a turbine engine combustion gas environment) and resolve conflicting aspects of relevant NaCl misconceptions. S.D.

A80-13070 * # **Decay of the zincate concentration gradient at an alkaline zinc cathode after charging.** H. E. Kautz and C. E. May (NASA, Lewis Research Center, Cleveland, Ohio). *Electrochemical Society, Meeting, Los Angeles, Calif., Oct. 14-19, 1979, Paper.* 19 p. 9 refs.

The study was carried out by observing the decay of the zincate concentration gradient at a horizontal zinc cathode after charging. This decay was found to approximate first order kinetics as expected from a proposed boundary layer model. The decay half life was shown to be a linear function of the thickness of porous zinc deposit on the cathode indicating a very rapid transport of zincate through porous zinc metal. The rapid transport is attributed to an electrochemical mechanism. The data also indicated a relatively sharp transition between the diffusion and convection transport regions. The diffusion of zincate ion through asbestos submerged in alkaline electrolyte was shown to be comparable with that predicted from the bulk diffusion coefficient of the zincate ion in alkali. (Author)

A80-20955 * # **Combustion of solid carbon rods in zero and normal gravity.** C. M. Spuckler, F. J. Kohl, R. A. Miller, C. A. Stearns (NASA, Lewis Research Center, Cleveland, Ohio), and K. J. De Witt (Toledo, University, Toledo, Ohio). *American Institute of Chemical Engineers, Annual Meeting, 72nd, San Francisco, Calif., Nov. 25-29, 1979, Paper.* 30 p. 11 refs.

In order to investigate the mechanism of carbon combustion, normal and zero gravity experiments were conducted in which spectroscopic carbon rods were resistance ignited and burned in an oxygen environment. Direct mass spectrometric sampling was used in the normal gravity tests to measure gas phase concentrations. The gas sampling probe was positioned near the circumference of the horizontally mounted carbon rods, either at the top or at angles of 45 or 90 deg from the top, and yielded concentration profiles of CO_2, CO, and O_2 as a function of distance from the carbon surface. The experimental concentrations were compared to those predicted by a stagnant film model. Zero gravity droptower tests were conducted in order to assess the effect of convection on the normal gravity combustion process. The ratio of flame diameter to rod diameter as a function of time for oxygen pressures of 5, 10, 15, and 20 psia was obtained for three different diameter rods. It was found that this ratio was inversely proportional to both the oxygen pressure and the rod diameter. (Author)

A80-35881 * **Durability testing of advanced catalysts and catalyst supports for gas turbine engine combustors.** R. M. Heck, M. Chang, H. W. Hess (Engelhard Industries, Inc., Edison, N.J.), and T. S. Mroz (NASA, Lewis Research Center, Cleveland, Ohio). *AIChE Symposium Series*, vol. 75, no. 188 1979, p. 83-94. 9 refs.

The paper presents new information on the durability of a CATCOM catalyst operating at low-emission combustion temperatures (about 1527 K) with a liquid fuel, No. 2 diesel. Information on the activity of No. 2 diesel after 1000 hr of aging is given. In addition, a unique in situ activity test developed for monitoring the subtle changes in the catalyst activity of the CATCOM catalyst is also detailed. The study demonstrated the feasibility of using a CATCOM catalyst in catalytically supported thermal combustion for extended operating periods. S.D.

A80-39640 * # **An interactive modular design for computerized photometry in spectrochemical analysis.** V. L. Bair (NASA, Lewis Research Center, Cleveland, Ohio). *Society for Analytical Chemists of Pittsburgh and Spectroscopy Society of Pittsburgh, Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Atlantic City, N.J., Mar. 10-14, 1980, Paper.* 15 p.

An interactive, top-down structured program design is described which produces a general flexible description of totally automatic photometry of emission spectra in an operating environment in which sample compositions and analysis procedures are low-volume and nonroutine. The use of this type of programming is illustrated by a project to computerize trace elemental determinations including the automated reading of spectrographic plates produced by a 3.4-m Ebert mount spectrograph using a dc-arc in an argon atmosphere. V.T.

A80-42190 * # **An analytical study of nitrogen oxides and carbon monoxide emissions in hydrocarbon combustion with added nitrogen - Preliminary results.** D. A. Bittker (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar.*

10-13, 1980, Paper 80-GT-60. 11 p. 19 refs. Members, $1.50; nonmembers, $3.00.

The influence of ground-based gas turbine combustor operating conditions and fuel-bound nitrogen (FBN) found in coal-derived liquid fuels on the formation of nitrogen oxides and carbon monoxide is investigated. Analytical predictions of NOx and CO concentrations are obtained for a two-stage, adiabatic, perfectly-stirred reactor operating on a propane-air mixture, with primary equivalence ratios from 0.5 to 1.7, secondary equivalence ratios of 0.5 or 0.7, primary stage residence times from 12 to 20 msec, secondary stage residence times of 1, 2 and 3 msec and fuel nitrogen contents of 0.5, 1.0 and 2.0 wt %. Minimum nitrogen oxide but maximum carbon monoxide formation is obtained at primary zone equivalence ratios between 1.4 and 1.5, with percentage conversion of FBN to NOx decreasing with increased fuel nitrogen content. Additional secondary dilution is observed to reduce final pollutant concentrations, with NOx concentration independent of secondary residence time and CO decreasing with secondary residence time; primary zone residence time is not observed to affect final NOx and CO concentrations significantly. Finally, comparison of computed results with experimental values shows a good semiquantitative agreement. A.L.W.

N80-12142*# Pennsylvania State Univ., University Park.
INVESTIGATION OF CRITICAL BURNING OF FUEL DROPLETS Final Report, 1 Sep. 1966 - 30 Jun. 1979
G. M. Faeth Jul. 1979 87 p refs
(Grant NGR-39-009-077)
(NASA-CR-159697) Avail: NTIS HC A04/MF A01 CSCL 21B

The general problem of spray combustion was investigated. The combustion of bipropellent droplets; combustion of hydrozine fuels; and combustion of sprays were studied. A model was developed to predict mean velocities and temperatures in a combusting gas jet. R.C.T.

N80-13193*# Tennessee Technological Univ., Cookeville. Dept. of Mechanical Engineering.
AMPLIFICATION OF REYNOLDS NUMBER DEPENDENT PROCESSES BY WAVE DISTORTION Final Report, 1 Jan. 1972 - 31 Oct. 1979
M. Ventrice Nov. 1979 59 p refs
(Grant NGR-43-003-015)
(NASA-CR-159732) Avail: NTIS HC A04/MF A01 CSCL 21B

The amplification of a Reynolds number dependent process by wave distortion and the possibility of applying the results to other similar Reynolds number dependent processes were investigated. The process investigated was that associated with the operation of a constant-temperature hot-wire anemometer. The application of vaporization limited combustion, the type of combustion typically associated with liquid propellant rocket engines, was studied. A series of experiments were carried out to determine the effect of wave distortion on a Reynolds number dependent process and to establish the analogy between the anemometer process and the combustion process. Parametric trends, behavior common to different chamber geometries, and stability boundaries were identified. The results indicate a high degree of similarity between the two processes and the possibility of using the anemometer system to investigate combustion instability. The nonlinear aspects of a Reynolds number dependent process appear to be the dominant mechanisms controlling instability. J.M.S.

A80-11754 * **Symposium /International/ on Combustion, 17th, Leeds University, Leeds, England, August 20-25, 1978, Proceedings.** Symposium sponsored by NASA, NSF, U.S. Navy, U.S. Army, U.S. Air Force, ERDA, et al.; NSF Grant No. ENG-78-18544; Contracts No. N00014-78-M-0053; No. NAS3-21311; No. ET-78-G-01-3642; Grant No. DAAK11-78-M-0007. Pittsburgh, Pa., Combustion Institute, 1979. 1491 p. $66. (For individual items see A80-11755 to A80-11824)

The Symposium focused on deflagration to detonation transition, coal combustion, turbulent combustion interactions, kinetics, furnace combustion, inhibition and ignition, flame structure and chemistry, combustion studies, measurement techniques, fire and explosion, engine combustion, soot, and propellants and explosives. Papers were presented on numerical modeling of the deflagration-to-detonation transition, the interaction between turbulence and combustion, turbulent flame propagation in premixed gases, spray evaporation in recirculating flow, dissociation of nitric oxide in shock waves, pollutant emissions from partially mixed turbulent flames, energy transfer and quenching rates of laser-pumped electronically excited alkalis in flames, a study of flammability limits using counterflow flames, the unified theory of explosions with fuel consumption, and the dynamics and radiant intensity of large hydrogen flames. A.T.

A80-35908 * # **CATCOM catalyst 5 atm 1000 hour aging study using No. 2 fuel oil.** I. T. Osgerby, B. A. Olson, and H. C. Lee (Engelhard Minerals and Chemicals Corp., Edison, N.J.). *U.S. Environmental Protection Agency, Workshop on Catalytic Combustion, 4th, Cincinnati, Ohio, May 14, 15, 1980, Paper.* 44 p. 45 refs. Contract No. NAS3-19416.

The durability of the CATCOM catalyst for use in catalytically supported thermal combustion has been demonstrated at 5 atm, complementing a previous 1000 hour durability study at 1 atm. Both of these studies were conducted at about 640 K air preheat temperature at a reference velocity of about 14 m/s; the adiabatic flame temperature of the fuel/air mixture was about 1530 K. The catalyst proved to be capable of low emissions operations after 1000 hours of diesel fuel aging. However, more severe deactivation occurred in the 5 atm test; this was attributed to a loss in kinetic (ignition) activity. B.J.

26 METALLIC MATERIALS

Includes physical, chemical, and mechanical properties of metals, e g , corrosion, and metallurgy

N80-10344*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ANALYSIS OF THE RESPONSE OF A THERMAL BARRIER COATING TO SODIUM AND VANADIUM DOPED COMBUSTION GASES

Robert A Miller 1979 23 p refs Presented at 8th Midwest High Temperature Chemistry Conf , Milwaukee, Wis , 4 6 Jun 1979 Sponsored in part by DOE
(Contract EF-77-A-01-2593)
(NASA-TM-79205; DOE/NASA/2593-79/7; E-090) Avail NTIS HC A02/MF A01 CSCL 11F

Published data on the behavior of zirconia-based thermal barrier coatings exposed to combustion gases doped with sodium and vanadium were analyzed with respect to calculated condensate dew points and melting points Coating temperatures, failure locations, and depths were reasonably well correlated Author

N80-11188*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

MECHANICAL PROPERTIES AND OXIDATION AND CORROSION RESISTANCE OF REDUCED-CHROMIUM 304 STAINLESS STEEL ALLOYS

Joseph R Stephens, Charles A Barrett, and Charles A Gyorgak Washington Nov 1979 22 p refs
(NASA-TP-1557; E-065) Avail NTIS HC A02/MF A01 CSCL 11F

An experimental program was undertaken to identify effective substitutes for part of the Cr in 304 stainless steel as a method of conserving the strategic element Cr Although special emphasis was placed on tensile properties, oxidation and corrosion resistance were also examined Results indicate that over the temperature range of -196 C to 540 C the yield stress of experimental austenitic alloys with only 12 percent Cr compare favorably with the 18 percent Cr in 304 stainless steel Oxidation resistance and in most cases corrosion resistance for the experimental alloys were comparable to the commercial alloy. Effective substitutes for Cr included Al, Mo, Si, Ti, and V, while Ni and Mn contents were increased to maintain an austenitic structure R.C.T.

N80-11189*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

EFFECT OF THERMALLY INDUCED POROSITY ON AN AS-HIP POWDER METALLURGY SUPERALLOY

R. L. Dreshfield and R. V. Miner, Jr Washington 1979 20 p refs To be presented at Ann. Meeting of the Am. Inst. of Mining, Met and Petol Engr., Las Vegas, Nev., 24-28 Feb. 1980
(NASA-TM-79263; E-178) Avail: NTIS HC A02/MF A01 CSCL 11F

The impact of thermally induced porosity on the mechanical properties of an as-hot-isostatically-pressed and heat treated pressing made from low carbon Astroloy was determined Porosity in the disk-shape pressing studied ranged from 2.6 percent at the bore to 1.4 percent at the rim Tensile, yield strength, ductility, and rupture life of the rim of the porous pressing was only slightly inferior to the rim of sound pressings The strength, ductility, and rupture life of the bore of the porous pressing was severely degraded compared to sound pressings. At strain ranges typical of commercial jet engine designs, the rim of the porous pressing had slightly inferior fatigue life to sound pressings. A.R.H.

N80-14232*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IMPROVED REFRACTORY COATINGS AND METHOD OF PRODUCING THE SAME Patent Application

W A Brainard and D R Wheeler, inventors (to NASA) Filed 12 Jul 1979 7 p
(NASA-Case-LEW-131[illegible]-1; US-Patent-Appl-SN-102003) Avail: NTIS HC A02/MF A01 [illegible]CL 11F

A thin sputtered film that exhibits improved adherence to a substrate and has improved friction and wear characteristics is described These improvements are achieved by coating the substrate by rf sputtering with a film of titanium carbide using an argon sputtering plasma. A small nitrogen partial pressure from about 0.5% to 2.5% is added in the initial stages of the deposition during which the interface is formed The improvements in adhesion of the titanium carbide coating to the substrate results from the presence of both titanium nitride and a nitride of the substrate in the interfacial region. NASA

N80-14234*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CORROSION RESISTANCE OF SODIUM SULFATE COATED COBALT-CHROMIUM-ALUMINUM ALLOYS AT 900 C, 1000 C, AND 1100 C

G J Santoro Nov 1979 28 p refs
(NASA-TM-79311; E-267) Avail: NTIS HC A03/MF A01 CSCL 11F

The corrosion of sodium sulfate coated cobalt alloys was measured and the results compared to the cyclic oxidation of alloys with the same composition, and to the hot corrosion of compositionally equivalent nickel-base alloys. Cobalt alloys with sufficient aluminum content to form aluminum containing scales corrode less than their nickel-base counterparts. The cobalt alloys with lower aluminum levels form CoO scales and corrode more than their nickel-base counterparts which form NiO scales. M.G.

N80-15234*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ADHESION AND FRICTION OF IRON-BASE BINARY ALLOYS IN CONTACT WITH SILICON CARBIDE IN VACUUM

Kazuhisa Miyoshi and Donald H Buckley Jan. 1980 13 p refs
(NASA-TP-1604; E-126) Avail NTIS HC A02/MF A01 CSCL 11F

Single pass sliding friction experiments were conducted with various iron base binary alloys (alloying elements were Ti, Cr, Mn, Ni, Rh, and W) in contact with a single crystal silicon carbide /0001/ surface in vacuum. Results indicate that atomic size and concentration of alloying elements play an important role in controlling adhesion and friction properties of iron base binary alloys. The coefficient of friction generally increases with an increase in solute concentration. The coefficient of friction increases linearly as the solute to iron atomic radius ratio increases or decreases from unity The chemical activity of the alloying elements was also an important parameter in controlling adhesion and friction of alloys, as these latter properties are highly dependent upon the d bond character of the elements. R.C.T.

N80-15235*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF SODIUM, POTASSIUM, MAGNESIUM, CALCIUM, AND CHLORINE ON THE HIGH TEMPERATURE CORROSION OF IN-100, U-700, IN-792, AND MAR M-509

Carl E. Lowell, Steven M Sidik, and Daniel L. Deadmore 1980 28 p refs Proposed for presentation at 25th Ann. Intern. Gas Turbine Conf., New Orleans, 9-13 Mar. 1980; sponsored by the ASME
(Contract EF-77-A-01-2593)
(NASA-TM-79309; E-265; DOE/NASA/2593-79/12) Avail: NTIS HC A03/MF A01 CSCL 07D

The effects of potential impurities such as Na, K, Mg, Ca, and Cl, in coal-derived liquid fuels on accelerated corrosion of IN-100, U-700, IN-792, and Mar M-509 were investigated using a Mach 0.3 burner rig for times to 200 hours in one hour cycles. These impurities were injected in combination as aqueous solutions into the combustor Other variables were time, temperature, and fuel to-air ratio The experimental matrix was a central composite fractional factorial design divided into blocks to allow modification of the design as data was gathered The extent of corrosion was determined by metal consumption The time exponent was near 1 0 for the least corrosion resistant alloys, U-700 and IN 100, near 0 8 for the moderately resistant IN 792, and close to Mar M-509 the most corrosion resistant alloy As anticipated corrosion rapidly increased with increasing temperature as well as Na and K concentrations, while corrosion decreased somewhat as the Ca concentration increased for all alloys Mg was beneficial for the Ni base alloys but had little effect on the Co-base alloy Surprisingly, the effect of increasing Cl was to decrease the corrosion of all alloys Little interaction among the dopants was noted A R H

N80-16141*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SCANNING-ELECTRON-MICROSCOPE STUDY OF NORMAL-IMPINGEMENT EROSION OF DUCTILE METALS

William A. Brainard and Joshua Salik Jan 1980 11 p refs (NASA-TP-1609; E-085) Avail: NTIS HC A02/MF A01 CSCL 11F

Scanning electron microscopy was used to characterize the erosion of annealed copper and aluminum surfaces produced by both single- and multiple-particle impacts Macroscopic 3 2 mm diameter steel balls and microscopic, brittle erodant particles were projected by a gas gun system so as to impact at normal incidence at speeds up to 140 m/sec During the impacts by the brittle erodant particles, at lower speeds the erosion behavior was similar to that observed for the larger steel balls At higher velocities, particle fragmentation and the subsequent cutting by the radial wash of debris created a marked change in the erosion mechanism Author

N80-16143*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SOME CONSIDERATIONS OF THE PERFORMANCE OF TWO HONEYCOMB GAS PATH SEAL MATERIAL SYSTEMS

Robert C. Bill and Lawrence T Shiembob 1980 29 p refs To be presented at the Ann. Meeting of the Am. Soc of Lubrication Engr., Anaheim, Calif., 5-8 May 1980 Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, and Pratt and Whitney Aircraft Group, East Hartford, Conn.
(NASA-TM-81398; AVRACOM-TR-79-33; E-032) Avail NTIS HC A03/MF A01 CSCL 11F

A standard Hastelloy-X honeycomb material and a pack aluminide coated honeycomb material were evaluated as to their performance as labyrinth seal materials for aircraft gas turbine engines. Consideration from published literature was given to the fluid sealing characteristics of two honeycomb materials in labyrinth seal applications, and their rub characteristics, erosion resistance, and oxidation resistance were evaluated. The increased temperature potential of the coated honeycomb material compared to the uncoated standard could be achieved without compromising the honeycomb material's rub tolerance, although there was some penalty in terms of reduced erosion resistance. Author

N80-17199*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CHEMICAL PROCESSES INVOLVED IN THE INITIATION OF HOT CORROSION OF B-1900 AND NASA-TRW VIA

George C. Fryburg, Fred J. Kohl, and Carl A. Stearns 1979 49 p refs Presented at 165th Meeting of the Electrochem. Soc., Los Angeles, 14-19 Oct. 1979
(NASA-TM-81399; E-308) Avail: NTIS HC A03/MF A01 CSCL 11F

Sodium sulfate induced hot corrosion of B-1900 and NASA-TRW VIA at 900 C was studied with special emphasis on the chemical reactions occurring during and immediately after the induction period. Thermogravimetric tests were run for set periods of time after which the samples were washed with water and water soluble metal salts and/or residual sulfates were analyzed chemically Element distributions within the oxide layer were obtained from electron microprobe X-ray micrographs A third set of samples were subjected to surface analysis by X-ray photoelectron spectroscopy. Evolution of SO2 was monitored throughout many of the hot corrosion tests Results are interpreted in terms of acid-base fluxing mechanisms F L

N80-17200*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ANISOTROPY OF NICKEL-BASE SUPERALLOY SINGLE CRYSTALS

Rebecca A MacKay (Case Western Reserve Univ., Cleveland), Robert L Dreshfield, and Ralph D Maier (Case Western Reserve Univ., Cleveland) 1980 17 p refs Prepared for Presentation at 4th Intern. Symp on Superalloys, Champion, Pa, 21-25 Sep 1980
(NASA-TM-81437; E-327) Avail NTIS HC A02/MF A01 CSCL 11F

The influence of orientation on the tensile and stress rupture behavior of 52 Mar-M247 single crystals was studied Tensile tests were performed at temperatures between 23 and 1093 C, stress rupture behavior was examined between 760 and 1038 C The mechanical behavior of the single crystals was rationalized on the basis of the Schmid factor contours for the operative slip systems and the lattice rotations which the crystals underwent during deformation The tensile properties correlated well with the appropriate Schmid factor contours The stress rupture lives at lower testing temperatures were greatly influenced by the lattice rotations required to produce cross slip A unified analysis was attained for the stress rupture life data generated for the Mar-M247 single crystals at 760 and 774 C under a stress of 724 MPa and the data reported for Mar-M200 single crystals tested at 760 C under a stress of 689 MPa Based on this analysis, the stereographic triangle was divided into several regions which were rank ordered according to stress rupture life for this temperature regime Author

N80-18156*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY STUDY OF A SOLAR SELECTIVE COATING SYSTEM USING BLACK COBALT OXIDE FOR HIGH TEMPERATURE SOLAR COLLECTORS

G. McDonald 1980 16 p refs Proposed for presentation at Intern. Conf. on Metal Coatings, San Diego, Calif., 21-25 Apr 1980; Sponsored by Am. Vacuum Soc.
(NASA-TM-81385; E-293) Avail: NTIS HC A02/MF A01 CSCL 10A

Black cobalt oxide coatings (high solar absorptance layer) were deposited on thin layers of silver or gold (low emittance layer) which had been previously deposited on oxidized (diffusion barrier layer) stainless steel substrates. The reflectance properties of these coatings were measured at various thicknesses of cobalt for integrated values of the solar and infrared spectrum. The values of absorptance and emittance were calculated from the measured reflectance values, before and after exposure in air at 650 C for approximately 1000 hours. Absorptance and emittance were interdependent functions of the weight of cobalt oxide. Also, these cobalt oxide/noble metal/oxide diffusion barrier coatings have absorptances greater than 0.90 and emittances of approximately 0.20 even after about 1000 hours at 650 C. Author

N80-18157*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF IMPURITIES IN COAL-DERIVED LIQUIDS ON ACCELERATED HOT CORROSION OF SUPERALLOYS Final Report

Daniel L. Deadmore and Carl E. Lowell Mar. 1980 30 p refs (Contract EF-77-A-01-2593)
(NASA-TM-81384; DOE/NASA/2593-79/13; E-292) Avail: NTIS HC A03/MF A01 CSCL 11F

A Mach 0.3 burner rig was used to determine the effects of potential coal derived liquid fuel impurity combustion of products on hot corrosion in IN-100, IN-792, IN-738, U-700, Mar M-509, and 304 stainless steel The impurities added as aqueous solutions to the combustor were salts of sodium, potassium, vanadium, molybdenum, tungsten, phosphorus, and lead Extent of attack was determined by metal consumption and compared to the effects of sodium alone Vanadium, molybdenum, tungsten, phosphorous, and lead in combination with sodium all resulted in increased attack as compared with sodium alone at some temperatures, apparently due in large part to the extension of the formation of liquid deposits Varying the sodium-potassium ratio had little effect for ratios less than 1 3 for which reduced, but measurable, attack was observed K L

N80-20370*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio

AN EXPERIMENTAL, LOW-COST, SILICON-ALUMINIDE HIGH TEMPERATURE COATING FOR SUPERALLOYS

Stanley G Young and Daniel L Deadmore 1980 16 p refs To be presented at the Intern Conf on Metal Coatings, San Diego, Calif 21-25 Apr 1980, sponsored by the Am Vacuum Soc

(NASA-TM-81455, E-385) Avail NTIS HC A02/MF A01 CSCL 11F

An evaluation of a duplex silicon slurry/aluminide coating is presented The coating is cyclically tested in Mach 1 combustion gases for oxidation and thermal fatigue resistance at 1093 C and in Mach 0.3 gases for hot-corrosion resistance at 900 C The base metal superalloys are VIA and B-1900 The coated B-1900 specimens performed much better in oxidation than similar specimens coated with aluminides and almost as well as the more expensive Pt-Al and MCrAlY (where M is Ni and/or Co) coatings deposited by the physical vapor deposition process The coating also provided good hot corrosion protection Metallographic, X ray, and electron microprobe studies are used to characterize the coating, determine failure mechanisms, and study some of the changes due to exposure M G

N80-21488*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

APPLICATION OF SUPERALLOY POWDER METALLURGY FOR AIRCRAFT ENGINES

R L Dreshfield and R V Miner, Jr 1980 21 p refs Proposed for presentation at Intern Powder Met Conf, Washington, D C, 22-27 Jun 1980

(NASA-TM-81466, E-395) Avail NTIS HC A02/MF A01 CSCL 11F

In the last decade, Government/Industry programs have advanced powder metallurgy-near-net-shape technology to permit the use of hot isostatic pressed (HIP) turbine disks in the commercial aircraft fleet These disks offer a 30% savings of input weight and an 8% savings in cost compared in cast-and-wrought disks Similar savings were demonstrated for other rotating engine components A compressor rotor fabricated from hot-die-forged-HIP superalloy billets revealed input weight savings of 54% and cost savings of 35% compared to cast-and-wrought parts Engine components can be produced from compositions such as Rene 95 and Astroloy by conventional casting and forging, by forging of HIP powder billets, or by direct consolidation of powder by HIP However, each process produces differences in microstructure or introduces different defects in the parts As a result, their mechanical properties are not necessarily identical Acceptance methods should be developed which recognize and account for the differences A.R.H

N80-21489*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

AN INVESTIGATION INTO THE ROLE OF ADHESION IN THE EROSION OF DUCTILE METALS

William A Brainard and Joshua Salik 1980 20 p refs Presented at the 35th Ann Meeting of the Am Soc. of Lubrication Engr, Anaheim, Calif, 5-8 May 1980

(NASA-TM-81458, E-028) Avail NTIS HC A02/MF A01 CSCL 11F

Existing theories of erosion of ductile metals based on cutting and deformation mechanisms predict no material removal at normal incidence which is contradictory to experience. Thus, other mechanisms may be involved The possible role of adhesive material transfer during erosion is investigated by both single particle impingement experiments and erosion by streams of particles Examination of the rebounding particles as well as the eroded surface yields evidence of a significant adhesive mechanism for the ductile metals investigated Author

N80-21490*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

TRIBOLOGICAL PROPERTIES OF SPUTTERED MoS SUB 2 FILMS IN RELATION TO FILM MORPHOLOGY

Talivaldis Spalvins Mar 1980 17 p refs Presented at the Intern Conf on Met Coatings, San Diego, 21-25 Apr 1980, sponsored by the Am Vacuum Soc

(NASA-TM-81465, E-394) Avail NTIS HC A02/MF A01 CSCL 11F

Thin sputter deposited MoS2 films in the 2000 to 6000 A thickness range have shown excellent lubricating properties, when sputtering parameters and substrate conditions are properly selected and precisely controlled The lubricating properties of sputtered MoS2 films are strongly influenced by their crystalline-amorphous structure, morphology and composition The coefficient of friction can range from 0.04 which is effective lubrication to 0.4 which reflects an absence of lubricating properties Visual screening and slight wiping of the as-sputtered MoS2 film can identify the integrity of the film An acceptable film displays a black sooty surface appearance whereas an unacceptable film has a highly reflective, gray surface and the film is hard and brittle Author

N80-21492*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

FOULING AND THE INHIBITION OF SALT CORROSION Final Report

Daniel L Deadmore and Carl E Lowell Apr 1980 16 p refs (Contract EF-77-A-01-2593)

(NASA-TM-81469; DOE/NASA/2593-80, E-401) Avail NTIS HC A02/MF A01 CSCL 11F

In an attempt to reduce fouling while retaining the beneficial effects of alkaline earth inhibitors on the hot corrosion of superalloys, the use of both additives and the intermittent application of the inhibitors were evaluated Additions of alkaline earth compounds to combustion gases containing sodium sulfate were shown to inhibit hot corrosion However, sulfate deposits can lead to turbine fouling in service. For that reason, dual additives and intermittant inhibitor applications were evaluated to reduce such deposit formation. Silicon in conjunction with varium showed some promise Total deposition was apparently reduced while the inhibition of hot corrosion by barium was unimpaired The intermittant application of the inhibitor was found to be more effective and controllable Author

N80-21493*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

EFFECTS OF FINE POROSITY ON THE FATIGUE BEHAVIOR OF A POWDER METALLURGY SUPERALLOY

R V Miner, Jr and R L Dreshfield 1980 25 p refs Presented at Ann Meeting of the Am Inst of Mining, Met and Petroleum Engr, Las Vegas, Nev, 24-28 Feb 1980

(NASA-TM-81448; E-367) Avail NTIS HC A02/MF A01 CSCL 11F

Hot isostatically pressed powder metallurgy Astroloy was obtained which contained 1.4 percent fine porosity at the grain boundaries produced by argon entering the powder container during pressing. This material was tested at 650 C in fatigue, creep fatigue, tension, and stress-rupture and the results compared with previous data on sound Astroloy The pores averaged about 2 micrometers diameter and 20 micrometers spacing. They did influence fatigue crack initiation and produced a more intergranular mode of propagation. However, fatigue life was not drastically reduced. A large 25 micrometers pore in one specimen resulting from a hollow particle did not reduce life by 60 percent. Fatigue behavior of the porous material showed typical correlation with tensile behavior. The plastic strain range life relation was reduced proportionately with the reduction in tensile ductility,

but the elastic strain range-life relation was little changed reflecting the small reduction in sigma sub u/E for the porous material.
R.C.T.

N80-22464*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTS OF YTTRIUM, ALUMINUM AND CHROMIUM CONCENTRATIONS IN BOND COATINGS ON THE PERFORMANCE OF ZIRCONIA-YTTRIA THERMAL BARRIERS
Stephan Stecura 1980 12 p refs Presented at Intern. Conf. on Metallurgical Coatings, San Diego, Calif., 21-25 Apr. 1980
(NASA-TM-81485; E-423) Avail: NTIS HC A02/MF A01 CSCL 11F

A cyclic furnace study was conducted on thermal barrier systems to evaluate the effects of yttrium, chromium, and aluminum in nickel-base alloy bond coatings and the effect of bond coating thickness on yttria-stabilized zirconia thermal barrier coating life. Without yttrium in the bond coatings, the zirconia coatings failed very rapidly. Increasing chromium and aluminum in the Ni-Cr-Al-Y bond coatings increased total coating life. This effect was not as great as that due to yttrium. Increased bond coat thickness was also found to increase life. Author

N80-23430*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRACTICAL APPLICATIONS OF SURFACE ANALYTIC TOOLS IN TRIBOLOGY
John Ferrante 1980 45 p refs Presented at the Intern. Lubrication Conf., San Francisco, 18-21 Aug. 1980, sponsored by ASME and ASLE
(NASA-TM-81484; E-422) Avail: NTIS HC A03/MF A01 CSCL 20K

A brief description of many of the widely used tools is presented. Of this list, those which have the highest applicability for giving elemental and/or compound analysis for problems of interest in tribology along with being truly surface sensitive (that is less than 10 atomic layers) are presented. The latter group is critiqued in detail in terms of strengths and weaknesses. Emphasis is placed on post facto analysis of experiments performed under real conditions (e.g., in air with lubricants). It is further indicated that such equipment could be used for screening and quality control. R.C.T.

N80-26426*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPROVED PFB OPERATIONS: 400-HOUR TURBINE TEST RESULTS
R. J. Rollbuhler, S. M. Benford, and G. R. Zellars 1980 23 p refs Presented at 6th Intern. Conf. on Fluidized Bed Combust., Atlanta, 9-11 Apr. 1980; sponsored by DOE, Elec. Power Res. Inst., EPA and TVA
(NASA-TM-81511; E-260) Avail: NTIS HC A02/MF A01 CSCL 11F

A pressurized fluidized bed (PFB) coal-burning reactor was used to provide hot effluent gases for operation of a small gas turbine. Preliminary tests determined the optimum operating conditions that would result in minimum bed particle carryover in the combustion gases. Solids were removed from the gases before they could be transported into the test turbine by use of a modified two stage cyclone separator. Design changes and refined operation procedures resulted in a significant decrease in particle carryover, from 2800 to 93 ppm (1.5 to 0.05 grains/std cu ft), with minimal drop in gas temperature and pressure. The achievement of stable burn conditions and low solids loadings made possible a 400 hr test of small superalloy rotor, 15 cm (6 in.) in diameter, operating in the effluent. Blades removed and examined metallographically after 200 hr exhibited accelerated oxidation over most of the blade surface, with subsurface alumina penetration to 20 micron m. After 400 hours, average erosion loss was about 25 micron m (1 mil). Sulfide particles, indicating hot corrosion, were present in depletion zones, and their presence corresponded in general to the areas of adherent solids deposit. Sulfidation appears to be a materials problem equal in importance to erosion. A.R.H.

N80-26433*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THREE DIMENSIONAL FINITE-ELEMENT ELASTIC ANALYSIS OF A THERMALLY CYCLED DOUBLE-EDGE WEDGE GEOMETRY SPECIMEN Final Report, 1 Jun. 1977 - 1 Jan. 1979
Sandra K. Drake, Richard J. Hill, Peter T. Bizon, Jeffrey L. Kladden, and Bruce P. Guilliams Mar. 1980 49 p refs Prepared in cooperation with AF Wright Aeronautical Labs., Wright-Patterson AFB, Ohio
(AF Proj. 3066)
(NASA-TM-80980; AD-A083245; AFWAL-TR-80-2013) Avail: NTIS HC A03/MF A01 CSCL 11/6

An elastic stress analysis was performed on a wedge specimen (prismatic bar with double-edge wedge cross-section) subjected to thermal cycles in fluidized beds. Five alloys (IN 100, Mar-M 200, Mar-M 302, NASA TAZ-8A, and Rene 80) subjected to the same thermal cycling condition were analyzed. This condition was alternate 3 minute immersions in fluidized beds maintained at 316 C and 1088 C (600 and 1990 F). The analyses were performed as a joint effort of two laboratories using different models and computer programs (NASTRAN and ISO3DQ). Stress, strain, and temperature results are presented. GRA

N80-31527*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADHERENCE OF ION BEAM SPUTTER DEPOSITED METAL FILMS ON H-13 STEEL
Michael J. Mirtich 1980 17 p refs Presented at the 27th Natl. Am. Vacuum Soc. Symp., Detroit, 14-17 Oct. 1980
(NASA-TM-81585; E-562) Avail: NTIS HC A02/MF A01 CSCL 11F

An electron bombardment argon ion source was used to sputter deposit 17 different metal and metal oxide films ranging in thickness from 1 to 8 micrometers on H-13 steel substrates. The film adherence to the substrate surface was measured using a tensile test apparatus. Comparisons in bond strength were made between ion beam, ion plating, and RF deposited films. A protective coating to prevent heat checking in H-13 steel dies used for aluminum die casting was studied. The results of exposing the coated substrates to temperatures up to 700 degrees are presented. R.K.G.

N80-32484* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH TOUGHNESS-HIGH STRENGTH IRON ALLOY Patent
Joseph R. Stephens and Walter R. Witzke, inventors (to NASA) Issued 29 Jul. 1980 4 p Filed 25 Jan. 1979 Supersedes N79-19145 (17 - 10, p 1255) Continuation-in-part of abandoned US Patent Appl. SN-803822, filed 6 Jun. 1977
(NASA-Case-LEW-12542-3; US-Patent-4,214,902; US-Patent-Appl-SN-007083; US-Patent-Class-75-124; US-Patent-Appl-SN-803822) Avail: US Patent and Trademark Office CSCL 11F

An iron alloy is provided which exhibits strength and toughness characteristics at cryogenic temperatures. The alloy consists essentially of about 10 to 16 percent by weight nickel, about 0.1 to 1.0 percent by weight aluminum, and 0 to about 3 percent by weight copper, with the balance being essentially iron. The iron alloy is produced by a process which includes cold rolling at room temperature and subsequent heat treatment. Official Gazette of the U.S. Patent and Trademark Office

N80-32486*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRACTURE TOUGHNESS OF BRITTLE MATERIALS DETERMINED WITH CHEVRON NOTCH SPECIMENS
J. L. Shannon, Jr., R. T. Bursey, D. Munz (Karlsruhe Univ.), and W. S. Pierce [1980] 17 p refs Proposed for presentation at the 5th Intern. Conf. on Fracture, Cannes, France, 29 Mar. - 3 Apr. 1981; sponsored by the International Congress on Fracture
(NASA-TM-81607; E-600) Avail: NTIS HC A02/MF A01 CSCL 11F

The use of chevron-notch specimens for determining the plane strain fracture toughness (K sub Ic) of brittle materials is discussed. Three chevron-notch specimens were investigated: short bar, short rod, and four-point-bend. The dimensionless stress intensity coefficient used in computing K sub Ic is derived for the short bar specimen from the superposition of ligament-dependent and ligament-independent solutions for the straight through crack, and also from experimental compliance calibrations. Coefficients for the four-point-bend specimen were developed by the same superposition procedure, and with additional refinement using the slice model of Bluhm. Short rod specimen stress intensity coefficients were determined only by experimental compliance calibration. Performance of the three chevron-notch specimens and their stress intensity factor relations were evaluated by tests on hot-pressed silicon nitride and sintered aluminum oxide. Results obtained with the short bar and the four-point-bend specimens on silicon nitride are in good agreement and relatively free of specimen geometry and size effects within the range investigated. Results on aluminum oxide were affected by specimen size and chevron-notch geometry, believed due to a rising crack growth resistance curve for the material. Only the results for the short bar specimen are presented in detail. M.G.

N80-32487*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF TWO-LAYER THERMAL BARRIER SYSTEMS ON DIRECTIONALLY SOLIDIFIED Ni-Al-Mo AND COMPARATIVE EFFECTS OF ALLOY THERMAL EXPANSION ON SYSTEM LIFE

Stephan Stecura Washington Oct. 1980 35 p refs
(NASA-TM-81604; E-453) Avail: NTIS HC A03/MF A01 CSCL 11F

A promising two-layer thermal barrier coating system (TBS), Ni-16.4Cr-5.1Al-0.15Y/ZrO2-6.1Y2O3 (all in weight percent), was identified for directionally solidified Ni-Al-Mo (gamma/gamma' alpha). In cyclic furnace tests at 1095 C this system on gamma/gamma' alpha was better than Ni-16. 4Cr-5.1Al-0. 15Y/ZrO2-7.8Y2O3 by about 50 percent. In natural gas - oxygen torch rig tests at 1250 C the ZrO2-6.1Y2O3 coating was better than the ZrO2-7.8Y2O3 coating by 95 percent, on MAR-M509 substrates and by 60 percent on gamma/gamma' alpha substrates. Decreasing the coefficient of thermal expansion of the substrate material from 17-18x10 to the -6 power/C (MAR-M200 + Hf and MAR-M509) to 11x10 to the -6 power/C (gamma/gamma' alpha) also resulted in improved TBS life. For example, in natural gas - oxygen torch rig tests at 1250 C, the life of Ni-16.4Cr-5.1Al-0.15Y/ZrO26.1Y2O3 was about 30 percent better on gamma/gamma' alpha than on MAR-M509 substrates. Thus compositional changes in the bond and thermal barrier coatings were shown to have a greater effect on TBS life than does the coefficient of thermal expansion. Author

N80-32488*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CREEP-RUPTURE BEHAVIOR OF SEVEN IRON-BASE ALLOYS AFTER LONG TERM AGING AT 760 DEG IN LOW PRESSURE HYDROGEN Final Report

Walter R. Witzke and Joseph R. Stephens Aug. 1980 40 p refs
(Contract EC-77-A-31-1040)
(NASA-TM-81534; DOE/NASA/1040-15; E-486) Avail: NTIS HC A03/MF A01 CSCL 11F

Seven candidate iron-base alloys for heater tube application in the Stirling automotive engine were aged for 3500 hours at 760 C in argon and hydrogen. Aging degraded the tensile and creep-rupture properties. The presence of hydrogen during aging caused additional degradiation of the rupture strength in fine grain alloys. Based on current design criteria for the Mod 1 Stirling engine, N-155 and 19-9DL are considered the only alloys in this study with stregnths adequate for heater tube service at 760 C. Author

N80-32489*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LONG-TIME CREEP BEHAVIOR OF THE TANTALUM ALLOY ASTAR 811C

William D Klopp, Robert H Titran, and Keith D Sheffler (Pratt and Whitney Aircraft, East Hartford, Conn.) Sep 1980 21 p refs
(NASA-TP-1691; E-041) Avail NTIS CSCL 11F

The high vacuum creep behavior of Astar 811C (Ta-8W-1Re-0.7Hf-0.025C) was studied over the temperature range 800 C to 1700 C as a function of stress, temperature, and grain size in order to develop a relation for predicting long term creep. Primary creep strain was related to time by the Garofalo exponential function, and a second exponential term was developed to describe the tertiary creep portion of the creep curve. No significant periods of secondary (linear) creep were observed. The creep curves were well expressed by a relation that includes terms for primary and tertiary creep. The initial and tertiary creep rates were obtained by differentiating the respective terms from the strain time relation and can be related to temperature by using a dual activation energy to account for lattice and dislocation core diffusion. The strain parameters were determined as power functions of the applied stress. A.R.H.

N80-33555*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LONG-TIME CREEP BEHAVIOR OF THE NIOBIUM ALLOY C-103

Robert H. Titran and William D. Klopp Oct. 1980 12 p refs
(NASA-TP-1727; E-224) Avail: NTIS HC A02/MF A01 CSCL 11F

The creep behavior of C-103 was studied as a function of stress, temperature, and grain size for test times to 19000 hr. Over the temperature range 827 to 1204 C and the stress range 6.89 to 138 MPa, only tertiary (accelerating) creep was observed. The creep strain epsilon can be related to time t by an exponential relation epsilon = epsilon(O) + K e raised to power (st) - 1), where epsilon (O) is initial creep strain, K is the tertiary creep strain parameter, and s is the tertiary creep rate parameter. The observed stress exponent 2.87 is similar to the three power law generally observed for secondary (linear) creep of Class I solid solutions. The apparent activation energy 374 kj/g mol is close to that observed for self diffusion of pure niobium. The initial tertiary creep rate was slightly faster for fine grained than for coarse-grained material. The strain parameter K can be expressed as a combination of power functions of stress and grain size and an exponential function of temperature. Strain time curves generated by using calculated values for K and s showed reasonable agreement with observed curves to strains of at least 4 percent. The time to 1 percent strain was related to stress, temperature, and grain size in a similar manner as the initial tertiary creep rate. R.K.G.

N80-33556*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IMPROVED BOND COATINGS FOR USE WITH THERMAL BARRIER COATINGS Final Report

Michael A. Gedwill Sep. 1980 45 p refs
(Contract EF-77-A-01-2593)
(NASA-TM-81567; DOE/NASA/2593-18; E-532) Avail: NTIS HC A03/MF A01 CSCL 11F

The potential for improving the durability of thermal barrier coatings (TBC's) being developed for coal derived fuel fired gas turbines was studied. Furnace oxidation behavior of plasma deposited bond coatings was improved by increasing the thickness from 0.010 cm to 0.015 cm and by depositing the coatings at 20 kW with argon 3.5 vol % hydrogen arc gas rather than at 11 kW with argon. The most oxidation resistant plasma deposited bond coatings were Ni-14, 1Cr-13.4Al-0.10Zr, Ni-14.3Cr-14.4Al-0.16Y, and Ni-15.8Cr-12.8Al-0.36Y on B-1900 + Hf and Ni-30.9Cr-11.1Al-0.48Y on MAR-M-509. The oxidation resistant bond coatings improved TBC life when the coatings were deposited on the specimens supported on a nail bed fixture during coating. Author

A80-10043 * # **The erosion/corrosion of small superalloy turbine rotors operating in the effluent of a PFB coal combustor. G,**

R. Zellars, S. M. Benford, A. P. Rowe, and C. E. Lowell (NASA, Lewis Research Center, Cleveland, Ohio). *U.S. Department of Energy and Electric Power Research Institute, Conference on Advanced Materials for Alternate Fuel Capable Directly Fired Heat Engines, Castine, Me., July 30-Aug. 3, 1979, Paper.* 25 p. 10 refs.

The operation of a turbine in the effluent of a pressurized fluidized bed (PFB) coal combustor presents serious materials problems. Synergistic erosion/corrosion and deposition/corrosion interactions may favor the growth of erosion-resistant oxides on blade surfaces, but brittle cracking of these oxides may be an important source of damage along heavy particle paths. Integrally cast alloy 713LC and IN792 + Hf superalloy turbine rotors in a single-stage turbine with 6% partial admittance have been operated in the effluent of a PFB coal combustor for up to 164 hr. The rotor erosion pattern exhibits heavy particle separation with severe erosion at the leading edge, pressure side center, and suction side trailing edge at the tip. The erosion distribution pattern gives a spectrum of erosion/oxidation/deposition as a function of blade position. The data suggest that preferential degradation paths may exist even under the targeted lower loadings (less than 20 ppm). S.D.

A80-10391 * # **Preliminary results of the mission profile life test of a 30 cm Hg bombardment thruster.** R. T. Bechtel (NASA, Lewis Research Center, Solar Electric Propulsion Office, Cleveland, Ohio) and E. L. James (Xerox Electro-Optical Systems, Pasadena, Calif.). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2078.* 14 p. 14 refs.

The paper deals with some preliminary results of the Mission Profile Life Test planned to conduct a program of long-term test segments of 30-cm diameter thrusters and power processing units under computer control. Thruster performance data and other operational characteristics taken at various times during a test segment are compared and the results are evaluated in light of the life-timing mechanisms. Thruster control algorithms are also presented. The first test segment completed 2700 hr of a planned 4000 hr test with a J-series 30-cm thruster. The last 1600 hr used a functional model power processing unit (PPU) operated in vacuum. The thruster-PPU was controlled by a computer with software developed to control start-ups, throttling, and variety of off-normal conditions. V.T.

A80-13067 * # **Metal-dielectric interactions.** D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio). *National Research Council, Conference on Electrical Insulation and Dielectric Phenomena, Whitehaven, Pa., Oct. 21-25, 1979, Paper.* 22 p. 15 refs.

There is a wide variety of situations wherein metals are in solid state contact with dielectric materials. The paper reviews some of the factors that influence solid state interactions for metals in contact with dielectric surfaces. Since surfaces play an important part in these reactions, the use of analytical tools in characterizing surfaces is discussed. Adhesion, friction, and wear are utilized as indicators of the nature of interfacial bonding between metals and dielectrics can be effectively determined with adhesion and friction force measurements. Films present on the surface, such as oxygen or water vapor, markedly alter adhesive bond strength which in turn affects friction force and interfacial fracture when attempts are made to separate the contact regions. Analytical surface tools such as the field ion microscope, Auger emission spectroscopy, and X-ray photoelectron spectroscopy are very effective in providing insight into the effect of contact on the surfaces of metals and dielectrics. S.D.

A80-13071 * # **Some TEM observations of Al2O3 scales formed on NiCrAl alloys.** J. Smialek (NASA, Lewis Research Center, Cleveland, Ohio) and R. Gibala (NASA, Lewis Research Center; Case Western Reserve University, Cleveland, Ohio). *Gordon Research Conference on Corrosion, New London, N.H., July 23-27, 1979, Paper.* 32 p. 26 refs.

The microstructural development of Al2O3 scales on NiCrAl alloys has been examined by transmission electron microscopy. Voids have been observed within grains in scales formed on a pure NiCrAl alloy. Both voids and oxide grains grew measurably with oxidation time at 1100 C. The size and amount of porosity decreased towards the oxide-metal growth interface. It was postulated that the voids resulted from an excess number of oxygen vacancies near the oxide-metal interface. Short-circuit diffusion paths were discussed in reference to current growth stress models for oxide scales. Transient oxidations of pure, Y-doped, and Zr-doped NiCrAl was also examined. Oriented alpha-(Al,Cr)2O3 and Ni(Al,Cr)2O4 scales often coexisted in layered structures on all three alloys. Close-packed oxygen planes and directions in the corundum and spinel layers were parallel. The close relationships between oxide layers provided a gradual transition from initial transient scales to steady state Al2O3 growth. (Author)

A80-13277 * # **Elevated temperature flow strength, creep resistance and diffusion welding characteristics of Ti-6Al-2Nb-1Ta-0.8Mo.** J. D. Whittenberger and T. J. Moore (NASA, Lewis Research Center, Materials and Structures Div., Cleveland, Ohio). *Metallurgical Transactions A - Physical Metallurgy and Materials Science,* vol. 10A, Nov. 1979, p. 1597-1605. 10 refs.

A study of the flow strength, creep resistance and diffusion welding characteristics of the titanium alloy Ti-6Al-2Nb-1Ta-0.8Mo has been conducted. Two mill-processed forms of this alloy were examined. The forged material had been processed above the beta transus (approximately 1275 K) while the rolled form had been subjected to work below the beta transus. Between 1150 and 1250 K, the forged material was stronger and more creep resistant than the rolled alloy. Both forms exhibit superplastic characteristics in this temperature range. Strain measurements during diffusion welding experiments at 1200 K reveal that weld interfaces have no measurable effect on the overall creep deformation. Significant deformation appears to be necessary to produce a quality diffusion weld between superplastic materials. A 'soft' interlayer inserted between faying surfaces would seemingly allow manufacture of quality diffusion welds with little overall deformation. (Author)

A80-14445 * **Hot corrosion of four superalloys - HA-188, S-57, IN-617, and TD-NiCrAl.** G. J. Santoro (NASA, Lewis Research Center, Cleveland, Ohio). *Oxidation of Metals,* vol. 13, Oct. 1979, p. 405-435. 18 refs.

Cyclic oxidation and hot corrosion tests of two cobalt-base and two nickel-base alloys are reported. The alloys were exposed to maximum temperatures of 900 and 1000 C in a Mach 0.3 burner rig whose flame was doped with various concentrations of sea salt and sodium sulfate for hot corrosion tests. The test data were subjected to a regression analysis for the development of model equations relating corrosion to temperature and for the effects of salt concentration and composition on corrosion. The corrosion resistance varied with temperature, sea salt concentration, and salt composition, concluding that the S-57 cobalt-base alloy was the most hot corrosion-resistant alloy, and the TD-NiCrAl nickel-base alloy was the least resistant. However, under straight oxidation conditions, the TD-NiCrAl was most resistant, while S-57 was the least resistant alloy. A.T.

A80-25274 * **Improved adhesion of sputtered refractory carbides to metal substrates.** D. R. Wheeler and W. A. Brainard (NASA, Lewis Research Center, Cleveland, Ohio). *Wear,* vol. 58, Feb. 1980, p. 341-358. 18 refs.

Sputtered coatings of the refractory metal carbides are of great interest for applications where hard wear-resistant materials are desired. The usefulness of sputtered refractory carbides is often limited in practice by spalling or interfacial separation. In this work improvements in the adherence of refractory carbides on iron, nickel and titanium base alloys were obtained by using oxidation, reactive sputtering or sputtered interlayers to alter the coating-substrate interfacial region. X-ray photoelectron spectroscopy and argon ion etching were used to characterize the interfacial regions, and an attempt was made to correlate adherence as measured in wear tests with the chemical nature of the interface. (Author)

A80-26465 * The effect of zirconium on the isothermal oxidation of nominal Ni-14Cr-24Al alloys. A. S. Kahn, C. E. Lowell, and C. A. Barrett (NASA, Lewis Research Center, Cleveland, Ohio). *Electrochemical Society, Journal*, vol. 127, Mar. 1980, p. 670-679. 20 refs.

The isothermal oxidation of Ni-14Cr-24Al-xZr-type alloys was performed in still air at 1100, 1150, and 1200 C for times up to 200 hr. The zirconium content of the alloys varied from 0-0.63 atom percent (a/o). The oxidized surfaces were studied by optical microscopy, X-ray diffraction, and scanning electron microscopy. The base alloy was an alumina former with the zirconium-containing alloys also developing some ZrO2. The addition of zirconium above 0.066 a/o increased the rate of weight gain relative to the base alloy. Due to oxide penetration, the weight gain increased with Zr content; however, the scale thickness did not increase. The Zr did increase the adherence of the oxide, particularly at 1200 C. The delta W/A vs. time data fit the parabolic model of oxidation. The specific diffusion mechanism operative could not be identified by analysis of the calculated activation energies. Measurements of the Al2O3 scale lattice constants yielded the same values for all alloys. (Author)

A80-29990 * # Effects of thermally induced porosity on an as-HIP powder metallurgy superalloy. R. L. Dreshfield and R. V. Miner, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Mining, Metallurgical and Petroleum Engineers, Annual Meeting, Las Vegas, Nev., Feb. 24-28, 1980, Paper.* 18 p.

The effect of thermally induced porosity on the mechanical properties of an as-hot-isostatically pressed and heat-treated pressing made from low carbon Astroloy is examined. Tensile, stress-rupture, creep, and low cycle fatigue tests were performed and the results were compared with industrial acceptance criteria. It is shown that the porous pressing has a porosity gradient from the rim to the bore with the bore having 1-1/2% greater porosity. Mechanical properties of the test ring below acceptance level are tensile reduction in area at room temperature and 538 C and time for 0.1% creep at 704 C. It is also found that the strength, ductility, and rupture life of the rim are slightly inferior to those of the rim of the sound pressings, while those of the bore are generally below the acceptable level. At strain ranges typical of commercial aircraft engines, the low cycle fatigue life of the rim of the porous pressings is slightly lower than that of the sound pressings. L.M.

A80-35495 * # Effects of fine porosity on the fatigue behavior of a powder metallurgy superalloy. R. V. Miner and R. L. Dreshfield (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Mining, Metallurgical and Petroleum Engineers, Annual Meeting, 109th, Las Vegas, Nev., Feb. 25-28, 1980, Paper.* 23 p. 14 refs.

Hot-isostatically-pressed powder-metallurgy Astroloy was obtained which contained 1.4 percent porosity at the grain boundaries produced by argon entering the powder container during pressing. This material was tested at 650 C in fatigue, creep-fatigue, tension, and stress-rupture and the results compared with data on sound Astroloy. They influenced fatigue crack initiation and produced a more intergranular mode of propagation but fatigue life was not drastically reduced. Fatigue behavior of the porous material showed typical correlation with tensile behavior. The plastic strain range-life relation was reduced proportionately with the reduction in tensile ductility, but the elastic strain range-life relation was changed little. (Author)

A80-35500 * # Preliminary study of a solar selective coating system using black cobalt oxide for high temperature solar collectors. G. McDonald (NASA, Lewis Research Center, Cleveland, Ohio). *American Vacuum Society, International Conference on Metallurgical Coatings, San Diego, Calif., Apr. 21-25, 1980, Paper.* 14 p. 8 refs.

Black cobalt oxide coatings were deposited on thin layers of silver or gold which had been deposited on oxidized stainless steel substrates. The reflectance properties of these coatings were measured at various thicknesses of cobalt oxide for integrated values of the solar and infrared spectrum. The values of absorptance and emittance were calculated from the measured reflectance values before and after exposure in air at 650 C for 1000 hours. Also, these cobalt oxide/noble metal/oxide diffusion barrier coatings have absorptances greater than 0.90 and emittances of approximately 0.20 even after about 1000 hours at 650 C. (Author)

A80-35501 * # An experimental, low-cost, silicon-aluminide high-temperature coating for superalloys. S. G. Young and D. L. Deadmore (NASA, Lewis Research Center, Cleveland, Ohio). *American Vacuum Society, International Conference on Metallurgical Coatings, San Diego, Calif., Apr. 21-25, 1980, Paper.* 14 p. 19 refs.

A duplex silicon-slurry/aluminide coating has been developed and cyclically tested in Mach 1 combustion gases for oxidation and thermal fatigue resistance at 1093 C and Mach 0.3 gases and hot-corrosion resistance at 900 C. The base-metal superalloys were VIA and B-1900. The coated B-1900 specimens were found to perform much better in oxidation than similar specimens coated with aluminides, and almost as well as the more expensive Pt-Al and MCrAlY (where M is Ni and/or Co) coatings deposited by the physical vapor deposition process. The coatings also provided good hot-corrosion protection. V.P.

A80-35900 * # Effects of yttrium, aluminum and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers. S. Stecura (NASA, Lewis Research Center, Cleveland, Ohio). *American Vacuum Society, International Conference on Metallurgical Coatings, San Diego, Calif., Apr. 21-25, 1980, Paper.* 10 p. 5 refs.

A cyclic furnace study was conducted on thermal barrier systems to evaluate the effects of yttrium, chromium and aluminum in nickel-base alloy bond coatings and the effect of bond coating thickness on yttria-stabilized zirconia thermal barrier coating life. Without yttrium in the bond coatings, the zirconia coatings failed very rapidly. Increasing chromium and aluminum in the Ni-Cr-Al-Y bond coatings increased total coating life. This effect was not as great as that due to yttrium. Increased bond coat thickness was also found to increase life. (Author)

A80-40962 * Stability of several oxide dispersion strengthened alloys and a directionally solidified gamma/gamma prime-alpha eutectic alloy in a thermal gradient. G. Staniek (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Cologne, West Germany) and J. D. Whittenberger (NASA, Lewis Research Center, Cleveland, Ohio). *Zeitschrift für Werkstofftechnik*, vol. 11, June 1980, p. 197-205. 16 refs. Research supported by the Alexander von Humboldt-Stiftung and Bundesministerium für Forschung und Technologie.

Thermal gradient testing of three oxide dispersion strengthened alloys (two Ni-base alloys, MA 754 and MA 6000 E, and the Fe-base MA 956) and the directionally solidified eutectic alloy, gamma/gamma prime-alpha, have been conducted. Experiments were carried out with maximum temperatures up to 1200 C and thermal gradients on the order of 100 C/mm. The oxide dispersion strengthened alloys were difficult to test because the thermal stresses promoted crack nucleation and growth; thus the ability of these alloys to maintain a thermal gradient may be limited. The stability of individual fibers in gamma/gamma prime-alpha was excellent; however, microstructural changes were observed in the vicinity of grain boundaries. Similar structures were also observed in isothermally annealed material; therefore thermal gradients do not affect the microstructure of gamma/gamma prime-alpha in any significant manner. (Author)

A80-42262 * # **Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of IN-100, U-700, IN-792, and MAR M-509.** C. E. Lowell, S. M. Sidik, and D. L. Deadmore (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-150.* 18 p. 15 refs. Members, $1.50; nonmembers, $3.00.

A80-51573 * # **Anisotropy of nickel-base superalloy single crystals.** R. A. MacKay, R. D. Maier (Case Western Reserve University, Cleveland, Ohio), and R. L. Dreshfield (NASA, Lewis Research Center, Cleveland, Ohio). *International Symposium on Superalloys, 4th, Champion, Pa., Sept. 21-25, 1980, Paper.* 15 p. 6 refs. Grant No. NsG-3246.

The effects of crystal orientation on the mechanical properties of single crystals of the nickel-based superalloy Mar-M247 are investigated. Tensile tests at temperatures from 23 to 1093 C and stress rupture tests at temperatures from 760 to 1038 C were performed for 52 single crystals at various orientations. During tensile testing between 23 and 760 C, single crystals with high Schmid factors were found to be favorably oriented for slip and to exhibit lower strength and higher ductility than those with low Schmid factors. Crystals which required large rotations to become oriented for cross slip were observed to have the shortest stress rupture lives at 760 C, while those which required little or no rotation had the longest lives. In addition, stereographic triangles obtained for Mar-M247 and Mar-M200 single crystals reveal that crystals with orientations near the -111 had the highest lives, those near the 001 had high lives, and those near the 011 had low lives.
A.L.W.

N80-13218*# Inco Research and Development Center, Suffern, N. Y.
CHARACTERIZATION OF AN OXIDE DISPERSION STRENGTHENED SUPERALLOY, MA-6000E, FOR TURBINE BLADE APPLICATIONS Final Report
Y. G. Kim and H. F. Merrick May 1979 37 p refs
(Contract NAS3-20093)
(NASA-CR-159493) Avail: NTIS HC A03/MF A01 CSCL 11F

Alloy MA 6000E was developed by the mechanical alloying process for turbine blade applications. The nominal composition of the experimental alloy is Ni-15CR-2Mo-4W-4.5Al- 2.5Ti-2Ta-.15Zr-.05C-.01B-1.1Y2O3. The 1000 hour rupture strength in the longitudinal direction is about 145 MPa at 1093 C and about 483 MPa at 760 C. The alloy displays normal three-stage creep behavior. Typically the creep elongation is 3.5% at 760 C and 2% at 1093 C. The alloy is notch ductile (K sub 1 = 3.5). The rupture properties of the alloy are not significantly degraded by thermal cycling or prior stress isothermal exposure. The alloy also has excellent longitudinal high and low cycle fatigue resistance. Limited testing indicates that MA 6000E posesses good off-axis mechanical properties. The transverse tensile elongation at 760 C is about 3%. The 100 hour transverse rupture strength is 331 MPa at 760 C and about 55 MPa at 1093 C.
A.R.H.

N80-14235*# AiResearch Mfg. Co., Phoenix, Ariz.
ABRADABLE COMPRESSOR AND TURBINE SEALS, VOLUME 1
D. V. Sundberg, R. E. Dennis, and L. G. Hurst May 1979 178 p
(Contract NAS3-20073)
(NASA-CR-159600; AiResearch-21-3213-1) Avail: NTIS HC A09/MF A01 CSCL 11A

The application and advantages of abradable coatings as gas-path seals in a general aviation turbine engine were evaluated for use on the high-pressure compressor, the high-pressure turbine, and the low-pressure turbine shrouds. Topics covered include: (1) the initial selection of candidate materials for interim full-scale engine testing; (2) interim engine testing of the initially selected materials and additional candidate materials; (3) the design of the component required to adapt the hardware to permit full-scale engine testing of the most promising materials; (4) finalization of the fabrication methods used in the manufacture of engine test hardware; and (5) the manufacture of the hardware necessary to support the final full-scale engine tests.
A.R.H.

N80-15233*# Pittsburgh Univ., Pa. Dept. of Metallurgical and Materials Engineering.
AN INVESTIGATION OF THE INITIATION STAGE OF HOT CORROSION IN Ni-BASE ALLOYS Semiannual Report, 1 Mar. 1979 - 31 Aug. 1979
T. T. Huang and G. H. Meier 1979 70047 p refs
(Grant NsG-3214)
(NASA-CR-159718; SETEC-MME-79-61; SAR-2) Avail: NTIS HC A03/MF A01 CSCL 11F

The commercial nickel base alloy, IN-738, and high purity laboratory alloys were prepared to simulate the effects of the major elements in IN-738. Results indicate that the initiation of hot corrosion attack of IN-738 and other similar alloys is the result of local penetration of molten salt through the protective oxide scale.
R.C.T.

N80-16142*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
STRESS CORROSION CRACKING EVALUATION OF MARTENSITIC PRECIPITATION HARDENING STAINLESS STEELS
T. S. Humphries and E. E. Nelson Jan. 1980 34 p refs
(NASA-TM-78257) Avail: NTIS HC A03/MF A01 CSCL 11F

The resistance of the martensitic precipitation hardening stainless steels PH13-8Mo, 15-5PH, and 17-4PH to stress corrosion cracking was investigated. Round tensile and c-ring type specimens taken from several heats of the three alloys were stressed up to 100 percent of their yield strengths and exposed to alternate immersion in salt water, to salt spray, and to a seacoast environment. The results indicate that 15-5PH is highly resistant to stress corrosion cracking in conditions H1000 and H1050 and is moderately resistant in condition H900. The stress corrosion cracking resistance of PH13-8Mo and 17-4PH stainless steels in conditions H1000 and H1050 was sensitive to mill heats and ranged from low to high among the several heats included in the tests. Based on a comparison with data from seacoast environmental tests, it is apparent that alternate immersion in 3.5 percent salt water is not a suitable medium for accelerated stress corrosion testing of these pH stainless steels.
A.R.H.

N80-18155*# United Technologies Research Center, East Hartford, Conn.
STUDY OF THE EFFECTS OF GASEOUS ENVIRONMENTS ON THE HOT CORROSION OF SUPERALLOY MATERIALS Final Report
John G. Smeggil and N. S. Bornstein 5 Feb. 1980 93 p
(Contract NAS3-21376)
(NASA-CR-159747; R79-914387-4) Avail: NTIS HC A05/MF A01 CSCL 11F

The effect of the gaseous corrodent NaCl on the high temperature oxidation and sodium sulfate induced hot corrosion behavior of alumina formers, chromia formers, and the superalloy B-1900 was examined. Isothermal experiments were conducted at 900 C and 1050 C in air in the presence and absence of NaCl vapors. Microstructural changes in oxide morphology and increased rates of oxidation were observed when NaCl(g) was present. It is hypothesized that the accelerated rates of oxidation are the result of removal of aluminum from the scale substrate interface and the weakening of the scale substrate bonds. The aluminum removed was redeposited on the surfaces in the form of alumina whiskers. For the superalloy B-1900, alumina whiskers are also formed, and the alloy oxidizes at catastrophic rates. In the case of Ni-25Cr alloy, NaCl vapors interact with the scale depleting it of chromium.
R.C.T.

N80-25416*# IIT Research Inst., Chicago, Ill. Materials Technology Div.
THERMAL FATIGUE AND OXIDATION DATA OF OXIDE DISPERSION-STRENGTHENED ALLOYS
K. E. Hofer, V. L. Hill, and V. E. Humphreys Mar. 1980 42 p refs
(Contract NAS3-17787)
(NASA-CR-159842; IITRI-M6001-82) Avail: NTIS HC A03/MF A01 CSCL 11F

Thermal fatigue and oxidation data were obtained 24 specimens representing 9 discrete oxide dispersion-strengthened alloy compositions or fabricating techniques. Double edge wedge specimens, both bare metal and coated for each systems, were cycled between fluidized beds maintained at 1130 C with a three minute immersion in each bed. The systems included alloys identified as 262 in hardness of HRC 38; 264 in hardness of HRC 38, 40 and 43; 265 HRC 39, 266 of HRC 37 and 40; 754; and 956. Specimens in the bare condition of 265 HRC 39 and 266 HRC 37 survived 6000 cycles without cracking on the small radius of the double edge wedge specimen. A coated specimen of 262 HRC 38, 266 HRC 37 and 266 HRC40 also survived 6000 cycles without cracking. A duplicate coated specimen of 262 HRC 38 alloy survived 5250 cycles before cracks appeared. All the alloys showed little weight change compared compared to alloys tested in prior programs. Authot

N80-26427*# Pittsburgh Univ., Pa. Dept. of Metallurgical and Materials Engineering.
HOT CORROSION OF Co-Cr, Co-Cr-Al, AND Ni-Cr ALLOYS IN THE TEMPERATURE RANGE OF 700-750 DEG C Semiannual Report, 1 Sep. 1979 - 29 Feb. 1980
K. T. Chiang and G. H. Meier Jun. 1980 29 p
(Grant NsG-3214)
(NASA-CR-159689; SAR-3) Avail: NTIS HC A03/MF A01 CSCL 11F

The effect of SO3 pressure in the gas phase on the Na2SO4 induced hot corrosion of Co-Cr, Ni-Cr, and Co-Cr-Al alloys was studied in the temperature range 700 to 750 C. The degradation of the Co-Cr and Ni-Cr alloys was found to be associated with the formation of liquid mixed sulfates (CoSO4-Na2SO4 or NiSO4-Na2SO4) which provided a selective dissolution of the Co or Ni and a subsequent sulfidation oxidation mode of attack which prevented the maintenance of a protective Cr2O3 film. A clear mechanism was not developed for the degradation of Co-Cr-Al alloys. A pitting corrosion morphology was induced by a number of different mechanisms. B.D.

N80-28499*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
MATERIALS FOR ADVANCED TURBINE ENGINES. VOLUME 1: POWER METALLURGY RENE 95 ROTATING TURBINE ENGINE PARTS Final Report
W. R. Pfouts, C. E. Shamblen, J. S. Mosier, R. E. Peebles, and R. W. Gorsler Jun. 1979 358 p 2 Vol.
(Contract NAS3-20074)
(NASA-CR-159802; R79AEG416-Vol-1) Avail: NTIS HC A16/MF A01 CSCL 11F

An attempt was made to improve methods for producing powder metallurgy aircraft gas turbine engine parts from the nickel base superalloy known as Rene 95. The parts produced were the high pressure turbine aft shaft for the CF6-50 engine and the stages 5 through 9 compressor disk forgings for the CFM56/F101 engines. A 50% cost reduction was achieved as compared to conventional cast and wrought processing practices. An integrated effort involving several powder producers and a major forging source were included. R.C.T.

N80-30482*# Pratt and Whitney Aircraft Group, West Palm Beach, Fla.
EVALUATION OF THE CYCLIC BEHAVIOR OF AIRCRAFT TURBINE DISK ALLOYS, PART 2 Contractor Report, Jul. 1978 - Mar. 1980
B. A. Cowles and J. R. Warren Jul. 1980 196 p refs
(Contract NAS3-21379)
(NASA-CR-165123; PWA-FR-13153-Pt-2) Avail: NTIS HC A09/MF A01 CSCL 11F

Several nickel-base aircraft turbine disk superalloys were evaluated at 650 C for resistance to fatigue crack initiation and propagation under cyclic and cyclic/dwell conditions. Controlled strain low cycle fatigue (LCF) and controlled load crack propagation tests were performed and results utilized to provide a direct comparison among the alloys. Tests were performed on selected alloys to evaluate the effects of hold times, mean stresses, stress-dwell cycle types, inert environment, and contractor test methods. At the lower total strain ranges of interest, the alloys exhibited generally increasing initiation life with increasing tensile strength for both cyclic (0.33 Hz) and cyclic/dwell (900-sec hold per cycle) conditions. Rank order of the alloys by LCF initiation life changed substantially at higher strain ranges, approaching the rank order expected from monotonic tensile ductilities. The effect of the 900 sec (15 min) hold time fatigue life varied significantly from alloy to alloy. Generally, the higher-strength, finer-grained alloys exhibited more significant reductions in fatigue life due to the dwell. The effects of mean strain were found to be negligible and the effects of mean stress were pronounced. At high strain ranges the mean stress was near zero and did not contribute to reduction in life. At low strain ranges, however, mean stresses were large and significant reductions in LCF lives occurred. L.F.M.

A80-44108 * // **Development of a high strength hot isostatically pressed /HIP/ disk alloy, MERL 76.** D. J. Evans and R. D. Eng (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.). *Metal Powder Industries Federation and American Powder Institute, International Powder Metallurgy Conference and Exhibition, Washington, D.C., June 22-27, 1980, Paper.* 13 p. Contract No. NAS3-20072.

A nickel-based powder metal disk alloy developed for use in advanced commercial gas turbines is described. Consideration is given to final alloy chemistry modifications made to achieve a desirable balance between tensile strength and stress rupture life and ductility. The effects of post-consolidation heat treatment are discussed, the preliminary mechanical properties obtained from full-scale turbine disks are presented. V.T.

A80-45825 * // **Development of exothermically cast single-crystal Mar-M 247 and derivative alloys.** T. E. Strangman, G. S. Hoppin, III (AiResearch Manufacturing Company of Arizona, Phoenix, Ariz.), C. M. Phipps (Jetshapes, Inc., Rockleigh, N.J.), K. Harris, and R. E. Schwer (Cannon-Muskegon Corp., Muskegon, Mich.). *Metallurgical Society of AIME and American Society for Metals, International Symposium on Superalloys, 4th, Champion, Pa., Sept. 21-25, 1980, Paper.* 14 p. 11 refs. Contract No. NAS3-20073. (AIRESEARCH-21-3469)

A low-cost, exothermic directional-solidification (DS) process was developed to produce single-crystal (SC) Mar-M 247 high-pressure turbine blades. Stress-rupture data indicated that SC Mar-M 247 provides only marginal improvements in longitudinal strength relative to the columnar grained DS material. Removal of grain boundary strengthening elements (B, C, Zr, Hf) from the Mar-M 247 composition (which are also melting point depressants) permitted the alloy to be solutioned at significantly higher temperatures. An order of magnitude improvement in rupture life relative to SC Mar-M 247 was observed for several derivative alloys at 103.5 MPa (15 KSI) and 1093 C. Rupture lives of the modified SC alloys were significantly affected by both alloy purity and heat treatment. Critical aspects of vacuum induction refining, exothermic casting technology, alloy development and heat treatment, which contributed to this new class of turbine blades, are reviewed. (Author)

27 NONMETALLIC MATERIALS

Includes physical, chemical, and mechanical properties of plastics, elastomers, lubricants, polymers, textiles, adhesives, and ceramic materials.

N80-13254*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CHARACTERIZATION AND PROPERTIES OF CONTROLLED NUCLEATION THERMOCHEMICAL DEPOSITED (CNTD) SILICON CARBIDE
Sunil Dutta, Roy W. Rice (Naval Res. Lab., Washington, D.C.), Henry C. Graham (AFML, Wright-Patterson AFB, Ohio), and Madan C. Mendiratta (Systems Res. Lab., Dayton, Ohio) 1978 24 p refs Presented at 80th Annual Meeting of the Basic Sci. Div. of the Am. Ceramic Soc., Detroit, 6-11 May 1978
(NASA-TM-79277; E-210) Avail: NTIS HC A02/MF A01 CSCL 11G

The microstructure of controlled nucleation thermochemical deposition (CNTD) - SiC material was studied and the room temperature and high temperature bend strength and oxidation resistance was evaluated. Utilizing the CNTD process, ultrafine grained (0.01-0.1 mm) SiC was deposited on W - wires (0.5 mm diameter by 20 cm long) as substrates. The deposited SiC rods had superior surface smoothness and were without any macrocolumnar growth commonly found in conventional CVD material. At both room and high temperature (1200 - 1380 C), the CNTD - SiC exhibited bend strength approximately 200,000 psi (1380 MPa), several times higher than that of hot pressed, sintered, or CVD SiC. The excellent retention of strength at high temperature was attributed to the high purity and fine grain size of the SiC deposit and the apparent absence of grain growth at elevated temperatures. The rates of weight change for CNTD - SiC during oxidation were lower than for NC-203 (hot pressed SiC), higher than for GE's CVD - SiC, and considerably below those for HS-130 (hot pressed Si3N4). The high purity, fully dense, and stable grain size CNTD - SiC material shows potential for high temperature structural applications; however problem areas might include: scaling the process to make larger parts, deposition on removable substrates, and the possible residual tensile stress. J.M.S.

N80-13256*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REACTIONS OF CALCIUM ORTHOSILICATE AND BARIUM ZIRCONATE WITH OXIDES AND SULFATES OF VARIOUS ELEMENTS
Isidor Zaplatynsky Oct. 1979 16 p refs Prepared for DOE
(NASA-TM-79272; E-192; DOE/NASA/2593-79/9) Avail: NTIS HC A02/MF A01 CSCL 11G

Calcium orthosilicate and barium zirconate were evaluated as the insulation layer of thermal barrier coatings for air cooled gas turbine components. Their reactions with various oxides and sulfates were studied at 1100 C and 1300 C for times ranging up to 400 and 200 hours, respectively. These oxides and sulfates represent potential impurities or additives in gas turbine fuels and in turbine combustion air, as well as elements of potential bond coat alloys. The phase compositions of the reaction products were determined by X-ray diffraction analysis. BaZrO3 and 2CaO-SiO2 both reacted with P2O5, V2O5, Cr2O3, Al2O3, and SiO2. In addition, 2CaO-SiO2 reacted with Na2O, BaO, MgO, and CoO and BaZrO3 reacted with Fe2O3. K.L.

N80-14249*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRICTION AND WEAR OF PLASMA-SPRAYED COATINGS CONTAINING COBALT ALLOYS FROM 25 DEG TO 650 DEG IN AIR
Harold E. Sliney and Thomas P. Jacobson 1979 20 p refs
(NASA-TM-79316; E-189) Avail: NTIS HC A02/MF A01 CSCL 11F

Four different compositions of self-lubricating, plasma-sprayed, composite coatings with calcium fluoride dispersed throughout cobalt alloy-silver matrices were evaluated on a friction and wear apparatus. In addition, coatings of the cobalt alloys alone and one coating with a nickel alloy-silver matrix were evaluated for comparison. The wear specimens consisted of two, diametrically opposed, flat rub shoes sliding on the coated, cylindrical surface of a rotating disk. Two of the cobalt composite coatings gave a friction coefficient of about 0.25 and low wear at room temperature, 400 and 650 C. Wear rates were lower than those of the cobalt alloys alone or the nickel alloy composite coating. However, oxidation limited the maximum useful temperature of the cobalt composite coating to about 650 C compared to about 900 C for the nickel composite coating. Author

N80-16165*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MECHANISMS OF LUBRICATION AND WEAR OF A BONDED SOLID LUBRICANT FILM
Robert L. Fusaro 1980 40 p refs Proposed for presentation at 35th Ann. Meeting of the Am. Soc. of Lubrication Engr., Anaheim, Calif., 5-8 May 1980
(NASA-TM-81396; E-296) Avail: NTIS HC A03/MF A01 CSCL 11H

To obtain a better understanding of how bonded solid lubricant films lubricate and wear (in general), the tribological properties of polyimide-bonded graphite fluoride films were studied (in specific). A pin-on-disk type of testing apparatus was used; but in addition to sliding a hemispherically tipped rider, a rider with a 0.95 mm diameter flat area was slid against the film. This was done so that a lower, less variable contact stress could be achieved. Two stages of lubrication occurred. In the first, the film supported the load. The lubricating mechanism consisted of the shear of a thin surface layer (of the film) between the rider and the bulk of the film. The second occurred after the bonded film had worn to the substrate, and consisted of the shear of very thin lubricant films between the rider and flat plateaus generated on the metallic substrate asperities. The film wear mechanism was strongly dependent on contact stress. M.M.M.

N80-17220*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LUBRICATION AND WEAR MECHANISMS OF POLYIMIDE-BONDED GRAPHITE FLUORIDE FILMS SUBJECTED TO LOW CONTACT STRESS
Robert L. Fusaro Jan. 1980 27 p refs
(NASA-TP-1584; E-9990) Avail: NTIS HC A03/MF A01 CSCL 11H

The tribological properties of polyimide-bonded graphite fluoride films were studied with a pin-on-disk friction apparatus. A 440 C HT stainless steel rider with a 0.95 millimeter diameter flat area was slid against the film in order to achieve a light, closely controlled contact stress. A 1 kilogram load was applied to this flat to give a projected contact stress of 14 megapascals. Two stages of lubrication were operating. In the first stage, the film supported the load and the lubricating mechanism appeared to be the shear of a thin surface layer of the film between the rider and the bulk of the film. The second stage began after the original film was worn away, and the lubricating mechanism appeared to be the shear of very thin lubricant layers between the flat area on the rider and flat plateaus generated on the sandblasted asperities of the metallic substrate. The major difference between the lubricating mechanisms of the hemispherical and flat riders was that the flat wore through the film much more slowly than did the hemisphere. K.L.

N80-18178*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WEAR PARTICLES OF SINGLE-CRYSTAL SILICON CARBIDE IN VACUUM
Kazuhisa Miyoshi and Donald H. Buckley Feb. 1980 24 p refs Submitted for publication
(NASA-TP-1624; E-077) Avail: NTIS HC A02/MF A01 CSCL 20B

Sliding friction experiments, conducted in vacuum with silicon carbide /000/ surface in contact with iron based binary alloys are described Multiangular and spherical wear particles of silicon carbide are observed as a result of multipass sliding The multiangular particles are produced by primary and secondary cracking of cleavage planes /000/, /10(-1)0/, and /11(-2)0/ under the Hertzian stress field or local inelastic deformation zone The spherical particles may be produced by two mechanisms (1) a penny shaped fracture along the circular stress trajectories under the local inelastic deformation zone, and (2) attrition of wear particles M.G.

N80-18181*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

REACTION BONDED SILICON NITRIDE PREPARED FROM WET ATTRITION-MILLED SILICON

Thomas P Herbell, Thomas K Glasgow, and Nancy J Shaw 1980 20 p refs Presented at the 4th Ann. Conf. on Composites and Advan Mater., Cocoa Beach, Fla., 20-24 Jan. 1980, sponsored by the Am. Ceram. Soc.

(NASA-TM-81428, E-329) Avail NTIS HC A02/MF A01 CSCL 11G

Silicon powder wet milled in heptane was dried, compacted into test bar shape, helium-sintered, and then reaction bonded in nitrogen-4 volume percent hydrogen. As-nitrided bend strengths averaged approximately 290 MPa at both room temperature and 1400 C. Fracture initiation appeared to be associated with subsurface flaws in high strength specimens and both subsurface and surface flaws in low strength specimens. Author

N80-18183*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARISON OF THE WEIGHT LOSS AND ADHERENCE OF NINE DIFFERENT POLYIMIDE FILMS THERMALLY AGED AT 315 C AND 350 C IN AIR

Robert L. Fusaro Mar. 1980 34 p refs

(NASA-TM-81381; E-286) Avail: NTIS HC A03/MF A01 CSCL 07D

Thermal exposure experiments at 315 and 350 C were performed in air on nine different types of polyimides applied to thin 304 stainless steel foils. The tests were conducted to determine which polyimide was the most thermally stable and adherent when subjected to long exposure times at elevated temperatures. One polyimide designated PIC-7 was found to be more thermally stable than the others; however, it did not possess the adherent properties of PIC-2 and PIC-5. It was concluded that as far as thermal stability and adherence are concerned, five of the polyimides are more suitable for high temperature applications than the other four. K.L.

N80-19263*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COMPARISON OF THE TRIBOLOGICAL PROPERTIES AT 25 C OF SEVEN DIFFERENT POLYIMIDE FILMS BONDED TO 301 STAINLESS STEEL

Robert L. Fusaro Feb. 1980 25 p refs

(NASA-TM-81413; E-328) Avail: NTIS HC A02/MF A01 CSCL 11G

A pin-on-disk type of friction and wear apparatus was used to study the tribological properties of seven different polyimide films bonded to AISI 301 stainless steel disks at 25 C. It was found that the substrate material was extremely influential in determining the lubricating ability of the polyimide films. All seven films spalled in less than 1000 cycles of sliding. This was believed to be caused by poor adherence to the 301 stainless steel or the inability of the films to withstand the high localized tensile stresses imparted by the deformation of the soft substrate under sliding conditions. The friction coefficients obtained for six of the polyimides varied between 0.21 to 0.32 while one varied between 0.32 to 0.39. K.L.

N80-20398*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

COMPOSITE WALL CONCEPT FOR HIGH TEMPERATURE TURBINE SHROUDS: SURVEY OF LOW MODULUS STRAIN ISOLATOR MATERIALS

Robert C Bill, Gordon P Allen, and Donald W Wisander Mar 1980 27 p refs Presented at the 25th Ann Intern Gas Turbine Conf., New Orleans, 9-13 Mar 1980, sponsored by ASME Prepared in cooperation with Army Aviation Research and Development Command, Cleveland

(NASA-TM-81443, AVRADCOM-TR-80-C-7, E-363) Avail NTIS HC A03/MF A01 CSCL 11A

Plasma sprayed yttria stabilized zirconium oxide turbine seal specimens, incorporating various low modulus porous metal strain isolator pads between the zirconium oxide and a dense metal substrate, were subjected to cyclic thermal shock testing. Specimens that had a low modulus pad composed of sintered FeNiCrAlY fibermetal survived 1000 thermal shock cycles without spalling of the ceramic A figure of merit for the low modulus pad materials taking into consideration the elastic modulus, thermal conductivity, strength, and oxidation resistance of the pad was proposed, and showed reasonable agreement with the thermal shock results A potential surface distress problem on the zirconium oxide, associated with nonuniform temperature distribution and rapid stress relaxation was identified One approach to solving the surface distress problem through application of laser surface fusion of the zirconium oxide layer showed some promise, but improvements in the laser surface fusion process are necessary to prevent process associated damage to the ceramic K.L.

N80-21532*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF OXIDE ADDITIONS AND TEMPERATURE ON SINTERABILITY OF MILLED SILICON NITRIDE

Alan Arias Apr. 1980 21 p refs

(NASA-TP-1644; E-243) Avail: NTIS HC A02/MF A01 CSCL 11D

Specimens of milled alpha-Si_3N_4 with 0 to 5.07 equivalent percent of oxide additions were pressureless sintered at 1650 to 1820 C for 4 hours in nitrogen while covered with powdered Si_3N_4 + SiO_2. Densities of less than or equal to 97.5 percent resulted with approximately 2.5 equivalent percent of MgO, CeO_2, Y_2O_3, and three mixtures involving these oxides. Densities of greater than or equal to 94 percent were obtained with approximately 0.62 equivalent percent of the same additives. At most temperatures, best sinterability (density maxima) was obtained with 1.2 to 2.5 equivalent percent additive. J.M.S.

N80-21534*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ADHESION, FRICTION, AND WEAR OF BINARY ALLOYS IN CONTACT WITH SINGLE-CRYSTAL SILICON CARBIDE

Kazuhisa Miyoshi and Donald H. Buckley 1980 24 p refs Prepared for the Intern. Joint Lubrication Conf., San Francisco, 18-21 Aug. 1980; cosponsored by ASME and the Am. Soc. of Lubrication Engr.

(NASA-TM-79282; E-221) Avail: NTIS HC A02/MF A01 CSCL 11F

Sliding friction experiments, conducted with various iron base alloys (alloying elements are Ti, Cr, Mn, Ni, Rh and W) in contact with a single crystal silicon carbide /0001/ surface in vacuum are discussed. Results indicate atomic size misfit and concentration of alloying elements play a dominant role in controlling adhesion, friction, and wear properties of iron-base binary alloys. The controlling mechanism of the alloy properties is as an intrinsic effect involving the resistance to shear fracture of cohesive bonding in the alloy. The coefficient of friction generally increases with an increase in solute concentration. The coefficient of friction increases as the solute-to-iron atomic radius ratio increases or decreases from unity. Alloys having higher solute concentration produce more transfer to silicon carbide than do alloys having low solute concentrations. The chemical activity of the alloying element is also an important parameter in controlling adhesion and friction of alloys. M.G.

N80-22493*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
STEADY-STATE WEAR AND FRICTION IN BOUNDARY LUBRICATION STUDIES
William R. Loomis and William R. Jones, Jr May 1980 11 p refs
(NASA-TP-1658; E-129) Avail NTIS HC A02/MF A01 CSCL 11G

A friction and wear study was made at 20 C to obtain improved reproducibility and reliability in boundary lubrication testing. Ester-base and C-ether-base fluids were used to lubricate a pure iron rider in sliding contact with a rotating M-50 steel disk in a friction and wear apparatus. Conditions included loads of 1/2 and 1 kg and sliding velocities of 3 6 to 18.2 m/min in a dry air atmosphere and stepwise time intervals from 1 to 250 min for wear measurements. The wear rate results were compared with those from previous studies where a single 25 min test period was used. Satisfactory test conditions for studying friction and wear in boundary lubrication for this apparatus were found to be 1 kg load; sliding velocities of 7.1 to 9.1 m/min (50 rpm disk speed); and use of a time stepwise test procedure. Highly reproducible steady-state wear rates and steady-state friction coefficients were determined under boundary conditions. Wear ratios and coefficients of friction were constant following initially high values during run-in periods. Author

N80-22494*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
FRICTION AND WEAR OF IRON-BASE BINARY ALLOYS IN SLIDING CONTACT WITH SILICON CARBIDE IN VACUUM
Kazuhisa Miyoshi and Donald H. Buckley May 1980 11 p refs
(NASA-TP-1612; E-260) Avail: NTIS HC A02/MF A01 CSCL 11F

Multipass sliding friction experiments were conducted with various iron base binary alloys in contact with a single crystal silicon carbide surface in vacuum. Results indicate that the atomic size and concentration of alloy elements play important roles in controlling the transfer and friction properties of iron base binary alloys. Alloys having high solute concentration produce more transfer than do alloys having low solute concentration. The coefficient of friction during multipass sliding generally increases with an increase in the concentration of alloying element. The change of friction with succeeding passes after the initial pass also increases as the solute to iron, atomic radius ratio increases or decreases from unity. Author

N80-23453*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY STUDY OF METHODS FOR PROVIDING THERMAL SHOCK RESISTANCE TO PLASMA-SPRAYED CERAMIC GAS-PATH SEALS
Robert C. Bill (AVRADCOM Res. and Technol. Labs.), Donald W. Wisander, and David E. Brewe (AVRADCOM Res. and Technol. Labs.) May 1980 24 p refs
(NASA-TP-1561; E-9941; AVRADCOM-TR-79-28) Avail: NTIS HC A02/MF A01 CSCL 11G

The cyclic thermal shock resistance of several outer air, gas path seal systems for high pressure turbines was evaluated. In all these systems, plasma sprayed, yttria stabilized ZrO2 was the ceramic constituent. The most promising approaches were those that had a porous-metal, low modulus pad as a strain isolator between the ceramic layer and the dense metal substrate. Cooling pins extending into the low modulus pad significantly reduced the oxidation rate of the porous metal and the extended seal life. The thermal shock resistance of ceramic layer was improved by increasing its porosity and by precracking it before thermal shock testing. Microstructural and probe studies suggested that the long term durability of the high-pressure turbine seal systems would be adversely affected if the metal ceramic interfaces exceeded about 800 C because some metallic species would rapidly diffuse. Author

N80-23456*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
FORMATION OF POROUS SURFACE LAYERS IN REACTION BONDED SILICON NITRIDE DURING PROCESSING
N. J. Shaw and T. K. Glasgow 1979 24 p refs Presented at the Fall Meeting of the Basic Sci. and Nucl. Div. of the Am. Ceramic Soc., New Orleans, 14-17 Oct. 1979
(NASA-TM-81493; E-431) Avail: NTIS HC A02/MF A01

An effort was undertaken to determine if the formation of the generally observed layer of large porosity adjacent to the as-nitride surfaces of reaction bonded silicon nitrides could be prevented during processing. Isostatically pressed test bars were prepared from wet vibratory milled Si powder. Sintering and nitriding were each done under three different conditions: (1) bars directly exposed to the furnance atmosphere; (2) bars packed in Si3N4 powder; (3) bars packed in Si3N4 powder. Packing the bars in either Si of Si3N4 powder during sintering retarded formation of the layer of large porosity. Only packing the bars in Si prevented formation of the layer during nitridation. The strongest bars (316 MPa) were those sintered in Si and nitrided in Si3N4 despite their having a layer of large surface porosity; failure initiated at very large pores and inclusions. The alpha/beta ratio was found to be directly proportional to the oxygen content; a possible explanation for this relationship is discussed. R.C.T.

N80-24437* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MODIFICATION OF THE ELECTRICAL AND OPTICAL PROPERTIES OF POLYMERS Patent
Michael J. Mirtich and James S. Sovey, inventors (to NASA) Issued 22 Apr. 1980 4 p Filed 7 Nov. 1978 Supersedes N70-11216 (17 - 02, p 0164)
(NASA-Case-LEW-13027-1; US-Patent-4,199,650; US-Patent-Appl-SN-958575; US-Patent-Class-428-421; US-Patent-Class-427-38; US-Patent-Class-427-40; US-Patent-Class-427-164; US-Patent-Class-428-474) Avail: US Patent and Trademark Office CSCL 11G

An electron bombardment argon ion source is used to form textured surfaces on polymide and fluorinated ethylene propylene polymers. This treatment improves the optical and electrical properties so that these polymers may be used in industrial and space applications.
Official Gazette of the U.S. Patent and Trademark Office

N80-26447*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LOW TEMPERATURE CROSS LINKING POLYIMIDES Patent Application
Tito T. Serafini and Peter Delviss, inventors (to NASA) Filed 20 Jun. 1980 14 p
(NASA-Case-LEW-12876-1; US-Patent-Appl-SN-161253) Avail: NTIS HC A02/MF A01 CSCL 07C

A way of forming a prepolymer polyimide which can be cross-linked at a relatively low temperature is disclosed. Usually a polyimide is formed by cross linking a prepolymer formed by reacting a polyfunctional ester, a polyfunctional amine, and an end-capping unit. By providing a styrene derivative end-capping unit, the prepolymer is curable at a temperature of about 175 to 245 C. NASA

N80-27483*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF W AND WC ON THE OXIDATION RESISTANCE OF YTTRIA-DOPED SILICON NITRIDE
Susan Schuon 30 Apr. 1980 12 p refs Presented at the Annual Meeting of the Am. Ceramic Soc., Chicago, 28-30 Apr. 1980
(NASA-TM-81528; E-9744) Avail: NTIS HC A02/MF A01 CSCL 07C

The effect of W and WC contamination on the oxidation and cracking in air of sintered Si3N4 - 8 w/o Y2O3 ceramics at 500, 750, and 1350 C is examined. A mixture of Si3N4 - 8Y2O3, milled with alumina balls, was divided into four portions. Three portions were doped with 2 w/o WC W, and 4 w/o W respectively, in order to simulate contamination during milling. The fourth portion was undoped and used on a control. The addition of W or WC did not affect the phase relationships in the system, as all bars with or without additions contained melilite as the major Si-Y-O-N phase after sintering. At 750 C, instability (rapid oxidation and cracking) of W-doped bars appears to have occurred as a result of oxidation of the tungsten containing melilite phase. No intermediate temperature instability was observed in bars containing 2 w/o WC or in bars with no additive. Specimens exposed at 1350 C had good oxidation resistance due to the formation of a protective siliceous oxide layer. A specimen containing 4 w/o W which was preoxidized at 1350 C had improved oxidation resistance at 750 C. The tendency towards oxidation and cracking of Si3N4 - 8 Y2O3 at 750 C is concluded to be related to tungsten content of the sintered bars. M.G.

N80-27484*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF STARTING POWDER CHARACTERISTICS ON DENSITY, MICROSTRUCTURE AND LOW TEMPERATURE OXIDATION BEHAVIOR OF A Si3N48w/o Y2O3 CERAMIC

Susan Schuon and Sunil Dutta 1980 23 p refs Presented at the Ann. Meeting of the Am. Ceramic Soc., Chicago, 28-30 Apr. 1980

(NASA-TM-81536; E-490) Avail: NTIS HC A02/MF A01 CSCL 07D

The densification and oxidation behavior of Si3N4 - 8w/oY2O3 prepared from three commercial starting powders were studied. Bars of SN 402, SN 502, and CP 85/15 were sintered for 3 to 4.5 hours at 1750 C. A second set was hot pressed for 2 hours at 1750 C. The microstructures were studied by transmission electron microscopy and scanning electron microscopy, densities were determined, and the phase compositions were determined by X-ray diffraction. Densification and microstructure were greatly influenced by the starting powder morphology and impurity content. Although SN 402 exhibited the maximum weight lose, the highest sintered and hot pressed densities were obtained with this powder. All powders had both equiaxed and elongated grains. Sintered bars were composed of beta silicon nitride and n-melelite. In contrast, hot pressed bars contained beta silicon nitride, H-phase, and J-phase, but no melelite. Yttria distribution in sintered bars was related to the presence of cation impurities such as Ca, Fe, and Mg. A limited oxidation study at 750 C in air showed no instability in these Si3N4 - 8 w/oY2O3 specimens, regardless of startin powder. Author

N80-28524*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CHARACTERIZATION OF PMR-15 POLYIMIDE COMPOSITION IN THERMO-OXIDATIVELY EXPOSED GRAPHITE FIBER COMPOSITES

William B. Alston 1980 19 p refs Proposed for Presentation at 12th Natl. SAMPE Tech. Conf., Seattle, 7-9 Oct. 1980

(NASA-TM-81565, AVRADCOM-TR-80-C-10; E-527) Avail: NTIS HC A02/MF A01 CSCL 09C

The contributions of individual resin components to total resin weight loss in 600 F air aged Celion 6000/PMR-15 polyimide composites were determined from the overall resin weight loss in the composite by chemically separating the PMR-15 matrix resin into its monomeric components. The individual resin components were also analyzed by spectroscopic techniques in order to elucidate curing and degradation mechanisms of the PMR-15 matrix resin. The isothermal weight loss of the individual resin components during prolonged 600 F thermo-oxidative aging of the composite was correlated to the changes observed in the Fourier Transform infrared spectra and Fourier Transform nuclear magnetic resonance spectra of the individual resin components. The correlation was used to identify the molecular site of the thermo-oxidative changes in PMR-15 polyimide matrix resin during 600 F curing the prolonged 600 F thermo-oxidative aging. Author

N80-29496*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CASTABLE HIGH TEMPERATURE REFRACTORY MATERIALS Patent Application

I Zaplatynsky, inventor (to NASA) Filed 30 Jul. 1980 5 p (NASA-Case-LEW-13080-1, US-Patent-Appl-SN-173521) Avail: NTIS HC A02/MF A01 CSCL 07D

A method is disclosed for fabricating chemically inert ceramic bodies that are both highly refractory and porous. A paste is formed by mixing alumina grain having uniform particle size with colloidal silica that is stabilized with ammonia. After drying, the cast body has sufficient green strength to be handled, and it is transferred to a furnace for curing. A green body prepared in this fashion does not undergo shrinkage during curing nor during prolonged subsequent heating. NASA

N80-32516* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

METHOD OF CROSS-LINKING POLYVINYL ALCOHOL AND OTHER WATER SOLUBLE RESINS Patent

Warren H. Phillipp, Charles E. May, Li-Chen Hsu, and Dean W. Sheibley, inventors (to NASA) Issued 19 Aug. 1980 4 p Filed 20 Dec. 1978 Supersedes N79-14172 (17 - 05, p 0571) (NASA-Case-LEW-13103-1; US-Patent-4,218,280; US-Patent-Appl-SN-971596; US-Patent-Class-156-272; US-Patent-Class-156-292; US-Patent-Class-264-22; US-Patent-Class-264-212; US-Patent-Class-204-159.11; US-Patent-Class-204-159.14; US-Patent-Class-427-44; US-Patent-Class-428-500; US-Patent-Class-429-139) Avail: US Patent and Trademark Office CSCL 07C

A self supporting sheet structure comprising a water soluble, noncrosslinked polymer such as polyvinyl alcohol which is capable of being crosslinked by reaction with hydrogen atom radicals and hydroxyl molecule radicals is contacted with an aqueous solution having a pH of less than 8 and containing a dissolved salt in an amount sufficient to prevent substantial dissolution of the noncrosslinked polymer in the aqueous solution. The aqueous solution is then irradiated with ionizing radiation to form hydrogen atom radicals and hydroxyl molecule radicals and the irradiation is continued for a time sufficient to effect crosslinking of the water soluble polymer to produce a water insoluble polymer sheet structure. The method has particular application in the production of battery separators and electrode envelopes for alkaline batteries.

Official Gazette of the U.S. Patent and Trademark Office

A80-12089 * **Boundary lubrication, thermal and oxidative stability of a fluorinated polyether and a perfluoropolyether triazine.** W. R. Jones, Jr. (NASA, Lewis Research Center, Cleveland, Ohio) and C. E. Snyder, Jr. (NASA, Lewis Research Center, Cleveland; USAF, Materials Laboratory, Wright-Patterson AFB, Ohio). *American Society of Lubrication Engineers, Annual Meeting, 34th, St. Louis, Mo., Apr. 30-May 3, 1979, Preprint 79-AM-1B-1.* 8 p. 25 refs.

Boundary lubricating characteristics, thermal stability and oxidation-corrosion stability were determined for a fluorinated polyether and a perfluoropolyether triazine. A ball-on-disk apparatus, a tensimeter and oxidation-corrosion apparatus were used. Results were compared to data for a polyphenyl ether and a C-ether. The polyether and triazine yielded better boundary lubricating characteristics than either the polyphenyl ether or C-ether. The polyphenyl ether had the greatest thermal stability (443 C) while the other fluids had stabilities in the range 389 to 397 C. Oxidation-corrosion results indicated the following order of stabilities: perfluoropolyether triazine greater than polyphenylether greater than C-ether greater than fluorinated polyether. (Author)

A80-12094 * **Effect of thermal aging on the tribological properties of polyimide films and polyimide-bonded graphite fluoride films.** R. L. Fusaro (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers, Annual Meeting, 34th, St. Louis, Mo., Apr. 30-May 3, 1979, Preprint 79-AM-3B-1.* 10 p. 10 refs.

The effect of thermal aging on the weight loss, adherence, friction and wear of polyimide films and polyimide-bonded graphite fluoride films applied to 440C-HT stainless steel disks and to 304 stainless steel thin foils was studied. The films were exposed at temperatures of 315, 345, 370 or 400 C for 100 hours or more and then evaluated at temperatures of 25, 315 or 345 C in atmospheres of dry or moist air. Polyimide films were found to be brittle after thermal exposure; but polyimide bonded graphite fluoride films possessed good adherence and gave low friction and wear results. Thus, polyimide-bonded graphite fluoride films appear to be good candidates for solid lubrication applications where long thermal soaks are prevalent. (Author)

A80-13063 * # **Characterization and properties of controlled nucleation thermochemical deposited /CNTD/ silicon carbide.** S. Dutta (NASA, Lewis Research Center, Cleveland, Ohio), R. W. Rice (U.S. Navy, Naval Research Laboratory, Washington, D.C.), H. C. Graham (USAF, Materials Laboratory, Wright-Patterson AFB, Ohio) and M. C. Mendiratta (Systems Research Laboratories, Inc., Dayton, Ohio). *American Ceramic Society, Annual Meeting, 18th, Detroit, Mich., May 6-11, 1978, Paper.* 22 p. 10 refs.

Results are presented for an investigation designed to characterize the microstructure of controlled nucleation thermomechanical deposition (CNTD) produced SiC material with respect to grain structure, stoichiometry, phase analysis, etc., and to evaluate the room-temperature and high-temperature fracture and oxidation behavior. By using the CNTD process, ultrafine-grained SiC is deposited on tungsten wires as substrates, with superior surface smoothness and without the macrocolumnar growth commonly observed in conventional CVD materials. The results suggest that the high-purity, fully dense, and stable grain size SiC material produced by CNTD shows potential for high-temperature structural applications, provided that pertinent problems are resolved. S.D.

A80-13065 * # **Mechanical and chemical effects of ion-texturing biomedical polymers.** A. J. Weigand and M. A. Cenkus (NASA, Lewis Research Center, Cleveland, Ohio). *Alliance for Engineering in Medicine, Annual Conference of Engineering in Medicine and Biology, 32nd, Denver, Colo., Oct. 6-10, 1979, Paper.* 27 p. 17 refs.

A80-18303 * # **Thermal barrier coatings for aircraft gas turbines.** R. A. Miller, S. R. Levine, and S. Stecura (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0302.* 6 p. 13 refs.

Improvements in gas turbine performance are approaching the limits imposed by alloy properties and excessive cooling air requirements. Thin ceramic coatings can increase the difference between gas temperature and metal temperature by several hundred degrees. Thus, they are potentially a major step forward in surface protection. These coatings offer the potential to reduce fuel consumption by permitting reduced coolant flow or higher turbine inlet temperature or to improve durability by reducing metal temperatures and transient thermal stresses. At NASA Lewis, in-house and contractual programs are in place to bring this promising technology to engine readiness in the early 1980's. Progress towards this goal is summarized in this paper. (Author)

A80-32086 * # **Liquid chromatographic characterization of PMR-15 resin and prepreg.** K. E. Reed (NASA, Lewis Research Center, Cleveland, Ohio). In: Rising to the challenge of the '80s; Annual Conference and Exhibit, 35th, New Orleans, La., February 4-8, 1980, Preprints. (A80-32058 12-24) New York, Society of the Plastics Industry, Inc., 1980, p. 26-E 1 to 26-E 4. 6 refs.

A liquid chromatographic method has been developed capable of providing a chemical fingerprint of PMR-15 resin solutions and prepreg. The amounts of two of the monomers can be quantified so their experimentally determined molar ratio can be compared to the formulated one. Only the monomers were detected in fresh resin solution, whereas several additional components, resulting from an association or reaction between the norbornenyl endcap and the amine, were detected in a resin solution aged for three days. Two commercial prepregs exhibited fingerprints similar to that of laboratory material, but three others contained additional components corresponding to higher esters and nadimides. (Author)

A80-32828 * # **Reaction bonded silicon nitride prepared from wet attrition-milled silicon.** T. P. Herbell, T. K. Glasgow, and N. J. Shaw (NASA, Lewis Research Center, Cleveland, Ohio). *American Ceramic Society, Annual Conference on Composites and Advanced Materials, 4th, Cocoa Beach, Fla., Jan. 20-24, 1980, Paper.* 19 p. 8 refs.

Silicon powder wet milled in heptane was dried, compacted into test bar shape, helium-sintered, and then reaction bonded in nitrogen-4 vol% hydrogen. As-nitrided bend strengths averaged approximately 290 MPa at both room temperature and 1400 C. Fracture initiation appeared to be associated with subsurface flaws in high-strength specimens and both subsurface and surface flaws in low-strength specimens. (Author)

A80-35502 * # **Tribological properties of sputtered MoS2 films in relation to film morphology.** T. Spalvins (NASA, Lewis Research Center, Cleveland, Ohio). *American Vacuum Society, International Conference on Metallurgical Coatings, San Diego, Calif., Apr. 21-25, 1980, Paper.* 14 p. 8 refs.

Thin sputter-deposited MoS2 films with thicknesses ranging from 2000 to 6000 A have shown excellent lubricating properties when sputtering parameters and substrate conditions are properly selected and controlled. The lubricating properties are strongly influenced by the crystalline-amorphous structure, morphology, and composition of the films. The coefficient of friction can range from 0.04 (which is effective lubrication) to 0.4 (no lubricating action). V.P.

A80-35899 * # **Effect of thermal cycling on ZrO2-Y2O3 thermal barrier coatings.** G. McDonald and R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio). *American Vacuum Society, International Conference on Metallurgical Coatings, San Diego, Calif., Apr. 21-25, 1980, Paper.* 7 p. 13 refs.

The paper studies the comparative life of plasma-sprayed ZrO2-Y2O3 thermal barrier coatings on NiCrAlY bond coats on René 41 in short (4 min) and long (57 min) thermal cycles at 1040 C in a 0.3-Mach flame. Attention is given to determining the effect of short- and long-duration cycles on ZrO2-Y2O3 coatings, the cause of any cycle frequency effects, and methods to improve tolerance to thermal stress. Short cycles greatly reduced the life of the ceramic coating in terms of time at temperatures as compared to longer cycles, the failed coating indicating compressive failure. The experiments and stress calculations show that repeatedly subjecting a ceramic coating to high rates of initial heating has a more destructive influence on the coating than sustained operation at temperature. The effect of such thermal compressive stresses might be minimized through coating deposition and thickness control and by turbine cycle measurement to keep starting heating rates below critical values. S.D.

A80-38963 * # **Development of improved-durability plasma sprayed ceramic coatings for gas turbine engines.** I. E. Sumner (NASA, Lewis Research Center, Engine Component Improvement Office, Cleveland, Ohio) and D. L. Ruckle (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1193.* 14 p. 6 refs.

An investigation is reported of improving the durability of plasma sprayed ceramic coatings for the vane platforms in the JT9d turbofan engine. The program aims for reduced fuel consumption of commercial aircraft engines; the use of improved strain tolerant microstructures and control of the substrate temperature during coating application are being evaluated. The initial burner rig tests at temperatures up to 1010 C indicated that improvements in cyclic life greater than 20:1 over previous ceramic coatings were achieved. Three plasma sprayed coating systems applied to first stage vane platforms in the high pressure turbine were subjected to a 1000-cycle JT9D engine endurance test with only minor damage occurring to the coatings. A.T.

A80-42085 * **Fracture toughness determination of Al2O3 using four-point-bend specimens with straight-through and chevron notches.** D. Munz, R. T. Bubsey, and J. L. Shannon, Jr. (NASA, Lewis Research Center, Strength of Materials Section, Cleveland, Ohio). *American Ceramic Society, Journal*, vol. 63, May-June 1980, p. 300-305. 28 refs.

A80-46099 * # **Effect of W and WC on the oxidation resistance of yttria-doped silicon nitride.** S. Schuon (NASA, Lewis Research Center, Cleveland, Ohio). *American Ceramic Society, Annual Meeting, Chicago, Ill., Apr. 28-30, 1980, Paper.* 10 p. 8 refs.

The effect of tungsten and tungsten carbide contamination on the oxidation and cracking in air of yttria-doped silicon nitride ceramics is investigated. Silicon nitride powder containing 8 wt % Y2O3 was doped with 2 wt % W, 4 wt % W, 2 wt % WC or left undoped, and sintered in order to simulate contamination during milling, and specimens were exposed in air to 500, 750 and 1350 C for various lengths of time. Scanning electron and optical microscopy and X-ray diffraction of the specimens in the as-sintered state reveals that the addition of W or WC does not affect the phase relationships in the system, composed of alpha and beta Si3N4, melilite and an amorphous phase. Catastrophic oxidation is observed at 750 C in specimens containing 2 and 4 wt % W, accompanied by the disappearance of alpha Si3N4 and melilite from the structure. At 1350 C, the formation of a protective glassy oxide layer was observed on all specimens without catastrophic oxidation, and it is found that pre-oxidation at 1350 C also improved the oxidation resistance at 750 C of bars doped with 4 wt % W. It is suggested that tungsten contamination from WC grinding balls may be the major cause of the intermediate-temperature cracking and instability frequently observed in Si3N4-8Y2O3. A.L.W.

A80-46100 * # **Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a Si3N4 - 8 w/o Y2O3 ceramic.** S. Schuon and S. Dutta (NASA, Lewis Research Center, Cleveland, Ohio). *American Ceramic Society, Annual Meeting, Chicago, Ill., Apr. 28-30, 1980, Paper.* 21 p. 7 refs.

A80-46153 **Sliding friction of some metallic glasses.** J. K. A. Amuzu (International Centre for Theoretical Physics, Trieste, Italy). *Journal of Physics D - Applied Physics*, vol. 13, July 14, 1980, p. L127-L129. 8 refs.

The coefficients of friction have been determined for some metallic glasses using a simple sliding friction rig. Calculated values of the coefficients have also been obtained from consideration of the simple adhesion model which predicts that the coefficient of friction is the ratio of the shear strength and the yield pressure of the contacting materials. Comparisons of the calculated and measured coefficients reveal large discrepancies, in marked contrast to the good agreement obtained for polymers. (Author)

A80-50696 * **Performance of Chevron-notch short bar specimen in determining the fracture toughness of silicon nitride and aluminum oxide.** D. Munz (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Cologne, West Germany), R. T. Bubsey, and J. L. Shannon, Jr. (NASA, Lewis Research Center, Strength of Materials Section, Cleveland, Ohio). *Journal of Testing and Evaluation*, vol. 8, May 1980, p. 103-107. 10 refs.

Ease of preparation and testing are advantages unique to the chevron-notch specimen used for the determination of the plane strain fracture toughness of extremely brittle materials. During testing, a crack develops at the notch tip and extends stably as the load is increased. For a given specimen and notch configuration, maximum load always occurs at the same relative crack length independent of the material. Fracture toughness is determined from the maximum load with no need for crack length measurement. Chevron notch acuity is relatively unimportant since a crack is produced during specimen loading. In this paper, the authors use their previously determined stress intensity factor relationship for the chevron-notch short bar specimen to examine the performance of that specimen in determining the plane strain fracture toughness of silicon nitride and aluminum oxide. (Author)

A80-51574 * # **Formation of porous surface layers in reaction bonded silicon nitride during processing.** N. J. Shaw and T. K. Glasgow (NASA, Lewis Research Center, Cleveland, Ohio). *American Ceramic Society, Fall Meeting, New Orleans, La., Oct. 14-17, 1979, Paper.* 22 p. 12 refs.

Microstructural examination of reaction bonded silicon nitride (RBSN) has shown that there is often a region adjacent to the as-nitrided surfaces that is even more porous than the interior of this already quite porous material. Because this layer of large porosity is considered detrimental to both the strength and oxidation resistance of RBSN, a study was undertaken to determine if its formation could be prevented during processing. All test bars studied were made from a single batch of Si powder which was milled for 4 hours in heptane in a vibratory mill using high density alumina cylinders as the grinding media. After air drying the powder, bars were compacted in a single acting die and hydropressed. (Author)

N80-13257*# Acurex Corp., Mountain View, Calif. Aerospace Systems Div.

SYNTHESIS OF IMPROVED POLYESTER RESINS Final Report

A. H. McLeod and C. B. Delano 5 Jul. 1979 83 p refs
(Contract NAS3-21374)
(NASA-CR-159665; FR-79-13/AS) Avail: NTIS HC A05/MF A01 CSCL 11G

Eighteen aromatic unsaturated polyester prepolymers prepared by a modified interfacial condensation technique were investigated for their solubility in vinyl monomers and ability to provide high char yield forming unsaturated polyester resins. The best resin system contained a polyester prepolymer of phthalic, fumaric and diphenic acids reacted with 2,7-naphthalene diol and 9,9-bis(4-hydroxyphenyl)fluorene. This prepolymer is very soluble in styrene, divinyl benzene, triallyl cyanurate, diallyl isophthalate and methylvinylpyridine. It provided anaerobic char yields as high as 41 percent at 800 C. The combination of good solubility and char yield represents a significant improvement over state-of-the-art unsaturated polyester resins. The majority of the other prepolymers had only low or no solubility in vinyl monomers. Graphite composites from this prepolymer with styrene were investigated. The cause for the observed low shear strengths of the composites was not determined. however 12-week aging of the composites at 82 C showed that essentially no changes in the composites had occurred. Author

N80-15263*# General Electric Co., Philadelphia, Pa. Space Sciences Lab.

SINTERED SILICON NITRODE RECUPERATOR FABRICATION Final Report

A. Gatti, W. S. Chiu, and L. R. McCreight Jan. 1980 40 p refs
(Contract DEN3-54)
(NASA-CR-159706; DOE/NASA/0054-79/1) Avail: NTIS HC A03/MF A01 CSCL 11B

The preliminary design anp a demonstration of the feasibility of fabricating submodules of an automotive Stirling engine recuperator for waste heat recovery at 370 C are described. Sinterable silicon nitride (Sialon) tubing and plates were fabricated by extrusion and hydrostatic pressing, respectively, suitable for demonstrating a potential method of constructing ceramic recuperator-type heat exchangers. These components were fired in nitrogen atmosphere to 1800 C without significant scale formation so that they can be used in the as fired condition A refractory glass composition (Al_2O_3 x 4 5 CaO MgO x 11SiO_2) was used to join and seal component parts by a brazing technique which formed strong recuperator submodules capable of withstanding repeated thermal cycling to 1370 C The corrosion resistance of these materials to Na_2SO_4 + NaCl carbon mixtures was also assessed in atmospheres of air hydrogen and CO_2-N_2-H_2O mixtures at both 870 C and 1370 C for times to 1000 hours No significant reaction was observed under any of these test conditions M M M

N80-15264*# TRW Defense and Space Systems Group, Redondo Beach Calif

ANALYSES OF MOISTURE IN POLYMERS AND COMPOSITES

L E Ryan and R W Vaughan 11 Jan 1980 99 p refs
(Contract NAS3-20406)
(NASA-CR-159745, TRW-31782-6082-RU 00) Avail NTIS HC A05/MF A01 CSCL 07C

A suitable method for the direct measurement of moisture concentrations after humidity/thermal exposure on state of the art epoxy and polyimide resins and their graphite and glass fiber reinforcements was investigated Methods for the determination of moisture concentration profiles, moisture diffusion modeling and moisture induced chemical changes were examined Carefully fabricated, precharacterized epoxy and polyimide neat resins and their AS graphite and S glass reinforced composites were exposed to humid conditions using heavy water (D2O), at ambient and elevated temperatures These specimens were fixtured to theoretically limit the D2O permeation to a unidirectional penetration axis The analytical techniques evaluated were (1) laser pyrolysis gas chromatography mass spectrometry, (2) solids probe mass spectrometry, (3) laser pyrolysis conventional infrared spectroscopy, and (4) infrared imaging thermovision The most reproducible and sensitive technique was solids probe mass spectrometry The fabricated exposed specimens were analyzed for D2O profiling after humidity/thermal conditioning at three exposure time durations R C T

N80-17221*# Aerotherm Acurex Corp., Mountain View, Calif Aerospace Systems Div

SYNTHESIS OF IMPROVED PHENOLIC RESINS Final Report

C B Delano and A H. McLeod 4 Sep 1979 115 p refs
(Contract NAS3-21368)
(NASA-CR-159724; FR-79-25/AS) Avail: NTIS HC A06/MF A01 CSCL 11G

Twenty seven addition cured phenolic resin compositions were prepared and tested for their ability to give char residues comparable to state-of-the-art phenolic resins. Cyanate, epoxy, allyl, acrylate, methacrylate and ethynyl derivatized phenolic oligomers were investigated. The novolac-cyanate and propargyl-novolac resins provided anaerobic char yields at 800 C of 58 percent. A 59 percent char yield was obtained from modified epoxy novolacs. A phosphonitrilic derivative was found to be effective as an additive for increasing char yields. The novolac-cyanate, epoxy-novolac and methacrylate-epoxy-novolac systems were investigated as composite matrices with Thornel 300 graphite fiber. All three resins showed good potential as composite matrices. The free radical cured methacrylate-epoxy-novolac graphite composite provided short beam shear strengths at room temperature of 93.3 MPa (13.5 ksi). The novolac-cyanate graphite composite produced a short beam shear strength of 74 MPa (10.7 ksi) and flexural strength of 1302 MPa (189 ksi) at 177 C. Air heat aging of the novolac-cyanate and epoxy novolac based composites for 12 weeks at 204 C showed good property retention. Author

N80-26448*# Mechanical Technology, Inc., Latham, N. Y.

HIGH TEMPERATURE SELF-LUBRICATING COATINGS FOR AIR LUBRICATED FOIL BEARINGS FOR THE AUTOMOTIVE GAS TURBINE ENGINE Final Report

Bharat Bhushan 1 Jul. 1980 232 p refs
(Contracts DEN3-43; EC-77-A-31-1040)
(NASA-CR-159848; DOE/NASA/0043-2) Avail: NTIS HC A11/MF A01 CSCL 13I

Coating combinations were developed for compliant surface bearings and journals to be used in an automotive gas turbine engine The coatings were able to withstand the sliding start/stops during rotor liftoff and touchdown and occasional short time, high speed rubs under representative loading of the engine Some dozen coating variations of CdO-graphite, Cr_2O_3 (by sputtering) and CaF_2 (plasma sprayed) were identified The coatings were optimized and they were examined for stoichiometry, metallurgical condition, and adhesion. Sputtered Cr_2O_3 was most adherent when optimum parameters were used and it was applied on an annealed (soft) substrate Metallic binders and interlayers were used to improve the ductility and the adherence R C T

N80-31552*# AiResearch Mfg Co., Phoenix, Ariz

THE 3500 HOUR DURABILITY TESTING OF COMMERCIAL CERAMIC MATERIALS Interim Report

W D Carruthers, D W. Richerson, and K W. Benn Jul 1980 237 p refs
(Contracts DEN3-27, EC-77-A-31-1040)
(NASA-CR-159785; DOE/NASA/0027-80/1, AiResearch-31-3575A) Avail: NTIS HC A11/MF A01 CSCL 11B

A two year durability testing program to evaluate four commercially available ceramic materials under simulated automotive gas turbine combustor discharge conditions was conducted. Conditions included extended cyclic thermal exposures up to 2500 F and 3500 hours Selected for evaluation were Norton NCX-34 hot pressed silicon nitride, AiResearch RBN 101 reaction bonded silicon nitride, Carborundum pressureless sintered d-SiC and British Nuclear Fuels, Ltd. Refel reaction sintered silicon carbide marketed by Pure Carbon Co. These materials initially were exposed to 350 hours/1750 cycles at 1200 and 1270 C (2200 and 2500 F). Subsequent exposure to 1050, 2100, and 3500 hours were performed on the materials maintaining 50 percent of baseline strength after the initial exposure. Additional evaluations of exposed bars included dimension changes, weight changes, dye penetrant, specific damping capacity changes, scanning electron microscope fractography and X-ray diffraction. S.F.

A80-10042 * # **Thick ceramic coating development for industrial gas turbines - A program plan.** J. W. Vogan and A. R. Stetson (Solar Turbines International, San Diego, Calif.). *U.S. Department of Energy and Electric Power Research Institute, Conference on Advanced Materials for Alternate Fuel Capable Directly Fired Heat Engines, Castine, Me., July 30-Aug. 3, 1979, Paper.* 29 p. 42 refs. Contract No. DEN3-109. (SR79-M-4702-05)

A program plan on a NASA-Lewis funded program is presented, in which effectiveness of thick ceramic coatings in preventing hot corrosion and in providing thermal insulation to gas turbine engine components are to be investigated. Preliminary analysis of the benefit of the thermal insulating effect of this coating on decreasing cooling air and simplifying component design appears very encouraging. The program is in the preliminary stages of obtaining starting materials and establishing procedures. Numerous graphs, tables and photographs are included. S.D.

A80-13066 * # **State-of-the-art of SiAlON materials.** S. Dutta (NASA, Lewis Research Center, Cleveland, Ohio). *NATO, AGARD, Specialist Meeting on Ceramics for Turbine Engine Applications, Cologne, West Germany, Oct. 7-12, 1979, Paper.* 21 p. 41 refs.

The state of the art of 'SiAlONs' is reviewed, noting that the term has become a generic one applied to Si_3N_4 based materials. Attention is given to work on phase relations, crystal structure, synthesis, fabrication, and properties of various SiAlONs. Also discussed are the essential features of compositions, fabrication methods, and microstructures. In addition, consideration is given to high temperature flexure strength, creep, fracture toughness, oxidation, and thermal shock resistance. Finally, these data are compared to those for some currently produced silicon nitride ceramics to assess the potential of SiAlON materials for use in advanced gas turbine engines. M.E.P.

A80-15720 * # **The effects of strain and temperature on the dynamic properties of elastomers** M. S. Darlow and A. J. Smalley (Mechanical Technology, Inc., Machinery Dynamics Section, Latham, N.Y.). *American Society of Mechanical Engineers, Design Engineering Technical Conference, St Louis, Mo., Sept. 10 12, 1979, Paper 79 DET 57.* 9 p. 8 refs. Members, $1.50, nonmembers, $3.00. Contract No. NAS3 18546.

This paper presents the results of a program of analysis and tests to determine the dynamic properties of elastomers as a function of strain and ambient temperature. Measurements were also made to determine the temperature distribution in the elastomer samples during the tests. These measured properties were compared with analytical predictions based on a visco elastic model designed to take into account the self heating of the materials as a function of strain. The test method used was well established Base Excitation Resonant Mass Technique. The specimens tested were two cylindrical button compression specimens and a shear specimen. Strain was shown to be an important parameter in determining the dynamic properties of the elastomers. In general, these properties were much more sensitive to strain than to frequency. The self heating effect was found to account for a portion of the strain sensitivity of these properties. (Author)

A80-35575 * # **3500-hour durability testing of ceramic materials for automotive gas turbine engines.** W. D. Carruthers, D. W. Richerson, and K. W. Benn (AiResearch Manufacturing Company of Arizona, Phoenix, Ariz.). *U.S. Department of Energy and NASA, International Automotive Propulsion Systems Symposium, 5th, Dearborn, Mich., Apr. 14-18, 1980, Paper.* 27 p. 7 refs. Contract No. DEN3-27. (AIRESEARCH-31-3542)

A two-year durability program was performed by AiResearch Phoenix to evaluate four commercially available ceramic materials under simulated automotive gas turbine combustor discharge conditions. These conditions included extended cyclic thermal exposures up to 2500 F and 3500 hr. The four materials selected for evaluation were Norton NCX-34 hot pressed silicon nitride, AiResearch RBN 101 reaction bonded silicon nitride, Carborundum pressureless sintered alpha-SiC and Pure Carbon Co. (British Nuclear Fuels, Ltd.) Refel reaction sintered silicon carbide. These materials were initially exposed to 350 hr/1750 cycles at 1200 and 1370 C. Subsequent exposures to 1050, 2100 and 3500 hr were performed on those materials maintaining 50% of baseline strength after the initial exposure. Additional evaluations of exposed bars included dimensional and weight changes, dye penetrant, specific damping capacity changes, SEM fractography, and X-ray diffraction. (Author)

A80-39637 * # **Evaluation of present-day thermal barrier coatings for industrial/utility applications.** R. J. Bratton, S. K. Lau, and S. Y. Lee (Westinghouse Research and Development Center, Pittsburgh, Pa.). *American Vacuum Society, International Conference on Metallurgical Coatings, San Diego, Calif., Apr. 21-25, 1980, Paper.* 22 p. 12 refs. Research sponsored by the Electric Power Research Institute; Contract No. NAS3-21377.

Atmospheric burner rig tests have been conducted to evaluate the corrosion resistance of present-day thermal barrier coatings. The coatings are primarily plasma-sprayed and zirconia-based. Both duplex and graded coating systems were tested at a gas temperature of 2100 F and metal temperatures that range from 1475 F to 1650 F. The fuels ranged from clean GT No. 2 to that doped with impurity levels which simulate water-washed residual fuels. Results to date suggest that liquid sulfate condensates play an important role in the coating degradation mechanisms, whereas the role of vanadium and its salts is less clear. (Author)

28 PROPELLANTS AND FUELS

Includes rocket propellants, igniters, and oxidizers, storage and handling, and aircraft fuels

For related information see also *07 Aircraft Propulsion and Power*, *20 Spacecraft Propulsion and Power*, and *44 Energy Production and Conversion*

N80-13268*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
TEMPERATURE AND FLOW MEASUREMENTS ON NEAR-FREEZING AVIATION FUELS IN A WING-TANK MODEL
Robert Friedman and Francis J Stockemer 1980 18 p refs To be presented at the 25th Intern Gas Turbine Conf, New Orleans, 9-13 Mar 1980, sponsored by ASME
(NASA-TM-79285, E-156) Avail NTIS HC A02/MF A01 CSCL 21D

Freezing behavior, pumpability, and temperature profiles for aviation turbine fuels were measured in a 190-liter tank chilled to simulate internal temperature gradients encountered in commercial airplane wing tanks When the bulk of the fuel was above the specification freezing point, pumpout of the fuel removed all fuel except a layer adhering to the bottom chilled surfaces, and the unpumpable fraction depended on the fuel temperature near these surfaces When the bulk of the fuel was at or below the freezing point, pumpout ceased when solids blocked the pump inlet, and the unpumpable fraction depended on the overall average temperature. K L

N80-18205*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
INITIAL CHARACTERIZATION OF AN EXPERIMENTAL REFEREE BROADENED-SPECIFICATION (ERBS) AVIATION TURBINE FUEL
George M. Prok and Gary T. Seng Jan. 1980 10 p refs
(NASA-TM-81440, E-206) Avail. NTIS HC A02/MF A01 CSCL 21D

Characterization data and a hydrocarbon compositional analysis are presented for a research test fuel designated as an experimental referee broadened-specification aviation turbine fuel. This research fuel, which is a special blend of kerosene and hydrotreated catalytic gas oil, is a hypothetical representation of a future fuel should it become necessary to broaden current kerojet specifications. It is used as a reference fuel in research investigations into the effects of fuel property variations on the performance and durability of jet aircraft components, including combustors and fuel systems. J.M.S.

N80-20402* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ATOMIC HYDROGEN STORAGE Patent
John A. Woollam, inventor (to NASA) Issued 18 Mar. 1980 3 p Filed 29 Sep. 1977 Supersedes N78-19907 (16 - 10, p 1365) Division of U.S. Patent Appl. SN-67432, filed 13 Apr. 1976, US Patent-4,077,788
(NASA-Case-LEW-12081-2; US-Patent-4,193,827; US-Patent-Appl-SN-837794; US-Patent-Class-149-1; US-Patent-Class-423-648R; US-Patent-Appl-SN-676432) Avail: US Patent and Trademark Office CSCL 21D

Atomic hydrogen, for use as a fuel or as an explosive, is stored in the presence of a strong magnetic field in exfoliated layered compounds such as molybdenum disulfide or an elemental layer material such as graphite. The compound is maintained at liquid temperatures and the atomic hydrogen is collected on the surfaces of the layered compound which are exposed during delamination (exfoliation). The strong magnetic field and the low temperature combine to prevent the atoms of hydrogen from recombining to form molecules.

Official Gazette of the U.S. Patent and Trademark Office

N80-21551*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MECHANICAL IMPACT TESTS OF MATERIALS IN OXYGEN EFFECTS OF CONTAMINATION
Paul M. Ordin Washington Apr 1980 36 p refs
(NASA-TP-1571; E-047) Avail NTIS HC A03/MF A01 CSCL 20K

The effect of contaminants on the mechanical impact sensitivity of Teflon, stainless steel, and aluminum in a high-pressure oxygen environment was investigated Uncontaminated Teflon did not ignite under the test conditions. The liquid contaminants - cutting oil, motor lubricating oil, and toolmaker dye - caused Teflon to ignite. Raising the temperature lowered the impact energy required for ignition Stainless steel was insensitive to ignition under the test conditions with the contaminants used Aluminum appeared to react without contaminants under certain test conditions; however, contamination with cutting oil, motor lubricating oil and toolmakers dye increased the sensitivity of aluminum to mechanical impact. The grit contaminants silicon dioxide and copper powder did not conclusively affect the sensitivity of aluminum. A.R.H.

N80-23472*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE IMPACT OF FUELS ON AIRCRAFT TECHNOLOGY THROUGH THE YEAR 2000
Jack Grobman and Gregory M. Reck 1980 26 p refs Presented at the Intern Meeting and Tech Display Global Technol 2000, Baltimore, 5-11 May 1980, sponsored by AIAA
(NASA-TM-81492, E-429) Avail NTIS HC A03/MF A01 CSCL 21D

The impact that the supply, quality, and processing costs of future fuels may have on aircraft technology is assessed The potential range of properties for future jet fuels is discussed along with the establishment of a data base of fuel property effects on propulsion system components Also, the evolution and evaluation of advanced component technology that would permit the use of broader property fuels and the identification of technical and economic trade-offs within the overall fuel production-air transportation system associated with variations in fuel properties are examined M G

N80-25454*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
ANALYTICAL AND EXPERIMENTAL EVALUATIONS OF THE EFFECT OF BROAD PROPERTY FUELS ON COMBUSTORS FOR COMMERCIAL AIRCRAFT GAS TURBINE ENGINES
A. L. Smith Jun. 1980 20 p refs Presented at 16th Joint Propulsion Conf., Hartford, Conn., 30 Jun. - 2 Jul. 1980; sponsored by AIAA, ASME, and SAE
(NASA-TM-81496; E-433) Avail: NTIS HC A02/MF A01 CSCL 21D

The impacts of broad property fuels on the design, performance, durability, emissions, and operational characteristics of current and advanced combustors for commercial aircraft gas turbine engines were studied. The effect of fuel thermal stability on engine and airframe fuel system was evaluated. Tradeoffs between fuel properties, exhaust emissions, and combustor life were also investigated. Results indicate major impacts of broad property fuels on allowable metal temperatures in fuel manifolds and injector support, combustor cyclic durability, and somewhat lesser impacts on starting characteristics, lightoff, emissions, and smoke. E.D.K.

N80-27509*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
USE OF PETROLEUM-BASED CORRELATIONS AND ESTIMATION METHODS FOR SYNTHETIC FUELS
A. C. Antoine Jun. 1980 23 p refs
(NASA-TM-81533; E-485) Avail: NTIS HC A02/MF A01 CSCL 21D

Correlations of hydrogen content with aromatics content, heat of combustion, and smoke point are derived for some synthetic fuels prepared from oil and coal syncrudes. Comparing the results of the aromatics content with correlations derived for petroleum fuels shows that the shale-derived fuels fit the petroleum-based correlations, but the coal derived fuels do not. The correlations derived for heat of combustion and smoke point are comparable to some found for petroleum-based correlations. Calculated values of hydrogen content and of heat of combustion are obtained for the synthetic fuels by use of ASTM estimation methods. Comparisons of the measured and calculated values show biases in the equations that exceed the critical statistics values. Comparison of the measured hydrogen content by the standard ASTM combustion method with that by a nuclear magnetic resonance (NMR) method shows a decided bias. The comparison of the calculated and measured NMR hydrogen contents shows a difference similar to that found with petroleum fuels. Author

N80-27510*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ADVANCED FUEL SYSTEM TECHNOLOGY FOR UTILIZING BROADENED PROPERTY AIRCRAFT FUELS

G M Reck Jun. 1980 23 p refs Proposed for presentation at 12th Congr. of the Intern. Council of the Aeron. Sci., Munich, 13-17 Oct. 1980

(NASA-TM-81538, E-492) Avail: NTIS HC A02/MF A01 CSCL 21D

Possible changes in fuel properties are identified based on current trends and projections. The effect of those changes with respect to the aircraft fuel system are examined and some technological approaches to utilizing those fuels are described. R.C.T.

N80-29502*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOME ADVANTAGES OF METHANE IN AN AIRCRAFT GAS TURBINE

Robert W. Graham and Arthur J. Glassman 1980 18 p refs Proposed for presentation at Aerospace Congr., Los Angeles, 13-16 Oct. 1980; sponsored by ASAE

(NASA-TM-81559, E-520) Avail: NTIS HC A02/MF A01 CSCL 21D

Liquid methane, which can be manufactured from any of the hydrocarbon sources such as coal, shale biomass, and organic waste considered as a petroleum replacement for aircraft fuels. A simple cycle analysis is carried out for a turboprop engine flying a Mach 0.8 and 10, 688 meters (35,000 ft.) altitude. Cycle performance comparisons are rendered for four cases in which the turbine cooling air is cooled or not cooled by the methane fuel. The advantages and disadvantages of involving the fuel in the turbine cooling system are discussed. Methane combustion characteristics are appreciably different from Jet A and will require different combustor designs. Although a number of similar difficult technical problems exist, a highly fuel efficient turboprop engine burning methane appear to be feasible. A.R.H.

N80-31621* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN AND EVALUATION OF HIGH PERFORMANCE ROCKET ENGINE INJECTORS FOR USE WITH HYDROCARBON FUELS

A. J. Pavli *In* APL The 16th JANNAF Combust. Meeting, Vol. 2 Dec. 1979 p 617-643 refs (For primary document see N80-31588 22-28)

Avail: Issuing Activity CSCL 21/9

An experimental program to determine the feasibility of using a heavy hydrocarbon fuel as a rocket propellant is reported. A method of predicting performance of a heavy hydrocarbon in terms of to experimental test results. Combustion length effects were explored over a range of 21.6 cm. to 55.9 cm. Four injector types were tested, each over a range of mixture ratios. Further configuration modifications were obtained by reaming each injector several times to provide test data over a range of injector pressure drop. E.D.K.

A80-42193 * # **Temperature and flow measurements on near-freezing aviation fuels in a wing-tank model.** R. Friedman (NASA, Lewis Research Center, Cleveland, Ohio) and F. J. Stockemer (Lockheed-California Co., Burbank, Calif.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-63.* 12 p. 15 refs. Members, $1.50; nonmembers, $3.00.

Freezing behavior, pumpability, and temperature profiles for aviation turbine fuels were measured in a 190-liter tank, to simulate internal temperature gradients encountered in commercial airplane wing tanks. Two low-temperature situations were observed. Where the bulk of the fuel is above the specification freezing point, pumpout of the fuel removes all fuel except a layer adhering to the bottom chilled surfaces, and the unpumpable fraction depends on the fuel temperature near these surfaces. Where the bulk of the fuel is at or below the freezing point, pumpout ceases when solids block the pump inlet, and the unpumpable fraction depends on the overall average temperature. (Author)

A80-42195 * # **NASA Broad-Specification Fuels Combustion Technology Program - Status and description.** J. S. Fear (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-65.* 10 p. 8 refs. Members, $1.50; nonmembers, $3.00.

The use of 'broad-specification' fuels in aircraft gas turbine engines can be a significant factor in offsetting anticipated shortages of current-specification jet fuel in the latter part of the century. The changes in fuel properties accompanying the use of broad-specification fuels will tend to cause numerous emissions, performance, and durability problems in currently-designed combustion systems. The NASA Broad-Specification Fuels Combustion Technology Program is a contracted effort to evolve and demonstrate the technology required to utilize broad-specification fuels in current and next generation commercial Conventional Takeoff and Landing (CTOL) aircraft engines, and to verify this technology in full-scale engine tests in 1983. The program consists of three phases: Combustor Concept Screening, Combustor Optimization Testing, and Engine Verification Testing. (Author)

A80-41516 * # **Analytical and experimental evaluations of the effect of broad property fuels on combustors for commercial aircraft gas turbine engines.** A. L. Smith (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1204.* 19 p. 9 refs. NASA-supported research.

Analytical and experimental studies were conducted in three contract activities funded by the National Aeronautics and Space Administration, Lewis Research Center, to assess the impacts of broad property fuels on the design, performance, durability, emissions and operational characteristics of current and advanced combustors for commercial aircraft gas turbine engines. The effect of fuel thermal stability on engine and airframe fuel system was evaluated. Trade-offs between fuel properties, exhaust emissions and combustor life were also investigated. Results indicate major impacts of broad property fuels on allowable metal temperatures in fuel manifolds and injector support, combustor cyclic durability and somewhat lesser impacts on starting characteristics, lightoff, emissions and smoke. (Author)

N80-19284*# Southwest Research Inst., San Antonio, Tex. Mobile Energy Div.

FUEL QUALITY COMBUSTION ANALYSIS Final Report, 6 Oct. 1978 - Jul. 1979

D. W. Naegeli and C. A. Moses May 1979 50 p refs (Contract NAS3-21587)

(NASA-CR-162822; MED113) Avail: NTIS HC A03/MF A01 CSCL 21D

A high pressure research combustor operating over a wide range of burner inlet conditions was used to determine the effects

C -2

of fuel molecular structure on soot formation. Six test fuels with equal hydrogen content (12.8%) were blended to stress different molecular components and final boiling points. The fuels containing high concentrations (20%) of polycyclic aromatics and partially saturated polycyclic structures such as tetralin, produced more soot than would be expected from a hydrogen content correlation for typical petroleum based fuels. Fuels containing naphthenes such as decalin agreed with the hydrogen content correlation. The contribution of polycyclic aromatics to soot formation was equivalent to a reduction in fuel hydrogen content of about one percent. The fuel sensitivity to soot formation due to the polycyclic aromatic contribution decreased as burner inlet pressure and fuel/air ratio increased. R.C.T.

N80-22509*# Massachusetts Inst. of Tech., Cambridge. Dept. of Mechanical Engineering.
LABORATORY MEASUREMENTS IN A TURBULENT, SWIRLING FLOW Final Report
David P. Hoult Nov. 1979 52 p refs
(Grant NsG-3076)
(NASA-CR-159723) Avail: NTIS HC A04/MF A01 CSCL 21D

Measurements of soot inside a flame-tube burner using a special water-flushed probe are discussed. The soot is measured at a series of points at each burner, and upon occasion gaseous constitutents NO, CO, hydrocarbons, etc., were also measured. Four geometries of flame-tube burners were studied, as well as a variety of different fuels. The role of upstream geometry on the downstream pollutant formation was studied. It was found that the amount of soot formed in particularly sensitive to how aerodynamically clean the configuration of the burner is upstream of the injector swirl vanes. The effect of pressure on soot formation was also studied. It was found that beyond a certain Reynolds number, the peak amount of soot formed in the burner is constant. F.O.S.

N80-25453*# United Technologies Corp., East Hartford, Conn.
EXTERNAL FUEL VAPORIZATION STUDY, PHASE 1
E. J. Szetela and L. Chiappetta Jun. 1980 133 p refs
(Contract NAS3-21971)
(NASA-CR-159850; UTRC-R80-914607-12) Avail: NTIS HC A07/MF A01 CSCL 21D

A conceptual design study was conducted to devise and evaluate techniques for the external vaporization of fuel for use in an aircraft gas turbine with characteristics similar to the Energy Efficient Engine (E(3)). Three vaporizer concepts were selected and they were analyzed from the standpoint of fuel thermal stability, integration of the vaporizer system into the aircraft engine, engine and vaporizer dynamic response, startup and altitude restart, engine performance, control requirements, safety, and maintenance. One of the concepts was found to improve the performance of the baseline E(3) engine without seriously compromising engine startup and power change response. Increased maintenance is required because of the need for frequent pyrolytic cleaning of the surfaces in contact with hot fuel. R.C.T.

N80-30535*# United Technologies Research Center, East Hartford, Conn.
AUTOIGNITION CHARACTERISTICS OF AIRCRAFT-TYPE FUELS
Louis J. Spadaccini and John A. TeVelde Jun. 1980 88 p refs
(Contract NAS3-20066)
(NASA-CR-159886; R80-914617-1) Avail: NTIS HC A05/MF A01 CSCL 21D

The ignition delay characteristics of Jet A, JP 4 no. 2 diesel, cetane and an experimental referee broad specification (ERBS) fuel in air at inlet temperatures up to 1000 K, pressures of 10, 15, 20, 25 and 30 atm, and fuel air equivalence ratios of 0.3, 0.5, 0.7 and 1.0 were mapped. Ignition delay times in the range of 1 to 50 msec at freestream flow velocities ranging from 20 to 100 m/sec were obtained using a continuous flow test apparatus which permitted independent variation and evaluation of the effect of temperature, pressure, flow rate, and fuel/air ratio. The ignition delay times for all fuels tested appeared to correlate with the inverse of pressure and the inverse exponent of temperature. With the exception of pure cetane, which had the shortest ignition delay times, the differences between the fuels tested did not appear to be significant. The apparent global activation energies for the typical gas turbine fuels ranged from 38 to 40 kcal/mole, while the activation energy determined for cetane was 50 kcal/mole. In addition, the data indicate that for lean mixtures, ignition delay times decrease with increasing equivalence ratio. It was also noted that physical (apparatus dependent) phenomena, such as mixing (i.e., length and number of injection sites) and airstream cooling (due to fuel heating, vaporization and convective heat loss) can have an important effect on the ignition delay. R.K.G.

N80-31619* Hersh Acoustical Engineering, Chatsworth, Calif.
EFFECT OF GRAZING FLOW ON THE NONLINEAR ACOUSTIC BEHAVIOR OF HELMHOLTZ RESONATORS
A. S. Hersh *In* APL The 16th JANNAF Combust. Meeting, Vol. 2 Dec. 1979 p 579-603 refs (For primary document see N80-31588 22-28)
(Contract NAS3-19745)
Avail: Issuing Activity CSCL 21/9

A semi empirical fluid mechanical model is derived of the acoustic behavior of thin walled single orifice Helmholtz resonators in a grazing flow environment. The model assumes that the flow field incident to a resonator orifice consists of a spherical sound particle velocity field superimposed upon a mean grazing flow. The incident and cavity sound fields are connected in terms of an orifice discharge coefficient whose values are determined experimentally using the two microphone method. With regard to its application to rocket motor interiors, the most important finding of this study is that the acoustic impedance of Helmholtz resonators is affected by grazing flow when the product of the amplitude of the sound pressure incident to the resonator orifice and the rocket motor interior mean grazing flow speed are less than 0.5. For values greater than 0.5, the acoustic impedance is independent of the grazing flow. E.D.K.

A80-42192 * # **Effect of fuel molecular structure on soot formation in gas turbine engines.** D. W. Naegeli and C. A. Moses (Southwest Research Institute, San Antonio, Tex.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-62.* 8 p. 19 refs. Members, $1.50; nonmembers, $3.00. Contract No. NAS3-21587.

A high-pressure research combustor operating over a wide range of burner inlet conditions was used to determine the effects of fuel molecular structure on soot formation. Six test fuels with equal hydrogen content (12.8 percent) were blended to stress different molecular components and final boiling points. The fuels containing high concentrations (20 percent) of poly-cyclic aromatics and partially saturated polycyclic structures such as tetralin, produced more soot than would be expected from a hydrogen content correlation for typical petroleum based fuels. However, fuels containing naphthenes, such as decalin, agreed with the hydrogen content correlation. The contribution of polycylic aromatics to soot formation was equivalent to a reduction in fuel hydrogen content of about 1%. The fuel sensitivity to soot formation due to the polycyclic aromatic contribution decreased as burner inlet pressure and fuel/air ratio increased. (Author)

31 ENGINEERING (GENERAL)

Includes vacuum technology; control engineering; display engineering; and cryogenics.

N80-13317*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EVALUATION OF CLEANERS FOR PHOTOVOLTAIC MODULES EXPOSED IN AN OUTDOOR ENVIRONMENT Final Report
W. D. Knapp Oct. 1979 17 p refs
(Contract DE-AI01-79ET-20485)
(NASA-TM-79248; E-204; DOE/NASA/20485-79/5) Avail: NTIS HC A02/MF A01 CSCL 13H

Power recovery of silicone encapsulated and glass covered photovoltaic modules, exposed for two years to a suburban environment, was measured after washing with a variety of cleaners including detergents, abrasive soap, and hydrocarbon solvents. Silicone encapsulated modules in operating environments may experience significant power losses or require extensive periodic cleaning. Glass front-faced modules in similar situations are much less affected. Organic hydrocarbon solvents or abrasives were found to be about five times more effective than mild detergents in cleaning encapsulated modules. Author

N80-16232*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HOMOGENEOUS ALIGNMENT OF NEMATIC LIQUID CRYSTALS BY ION BEAM ETCHED SURFACES
E. G. Wintucky, R. Mahmood, and D. L. Johnson 19 Oct. 1979 19 p refs Presented at 156th Meeting of the Electrochem. Soc., Los Angeles, 15-19 Oct. 1979
(NASA-TM-81378; E-283) Avail: NTIS HC A02/MF A01 CSCL 20L

A wide range of ion beam etch parameters capable of producing uniform homogeneous alignment of nematic liquid crystals on SiO2 films are discussed. The alignment surfaces were generated by obliquely incident (angles of 5 to 25 deg) argon ions with energies in the range of 0.5 to 2.0 KeV, ion current densities of 0.1 to 0.6 mA sq cm and etch times of 1 to 9 min. A smaller range of ion beam parameters (2.0 KeV, 0.2 mA sq cm, 5 to 10 deg and 1 to 5 min.) were also investigated with ZrO2 films and found suitable for homogeneous alignment. Extinction ratios were very high (1000), twist angles were small (< or = 3 deg) and tilt-bias angles very small (< or = 1 deg). Preliminary scanning electron microscopy results indicate a parallel oriented surface structure on the ion beam etched surfaces which may determine alignment. Author

A80-25096 * # **Oxygen-enriched air for MHD power plants.** R. W. Ebeling, Jr., J. C. Cutting (Gilbert Associates, Inc., Reading, Pa.), and J. A. Burkhart (NASA, Lewis Research Center, Cleveland, Ohio). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 18th, Butte, Mont., June 18-20, 1979, Preprints. (A80-25061 09-31) Bozeman, Mont., Montana State University, 1979, p. G.1.1-G.1.9. 16 refs. Research supported by the U.S. Department of Energy.

Cryogenic air-separation process cycle variations and compression schemes are examined. They are designed to minimize net system power required to supply pressurized, oxygen-enriched air to the combustor of an MHD power plant with a coal input of 2000 MWt. Power requirements and capital costs for oxygen production and enriched air compression for enrichment levels from 13 to 50% are determined. The results are presented as curves from which total compression power requirements can be estimated for any desired enrichment level at any delivery pressure. It is found that oxygen enrichment and recuperative heating of MHD combustor air to 1400 F yields near-term power plant efficiencies in excess of 45%. A minimum power compression system requires 167 MW to supply 330 lb of oxygen per second and costs roughly 100 million dollars. Preliminary studies show MHD/steam power plants to be competitive with plants using high-temperature air preheaters burning gas. L.M.

N80-15300*# Massachusetts Inst. of Tech., Cambridge. Dept. of Materials Science and Engineering.
DIRECTIONAL SOLIDIFICATION AT ULTRA-HIGH THERMAL GRADIENT Final Report
M. C. Flemings, D. S. Lee, and M. A. Neff Jan. 1980 34 p refs
(Grant NsG-3046)
(NASA-CR-159797) Avail: NTIS HC A03/MF A01 CSCL 13H

A high gradient controlled solidification (HGC) furnace was designed and operated at gradients up to 1800 C/cm to continuously produce aluminum alloys. Rubber 'O' rings for the water cooling chamber were eliminated, while still maintaining water cooling directly onto the solidified metal. An HGC unit for high temperature ferrous alloys was also designed. Successful runs were made with cast iron, at thermal gradients up to 500 C/cm. K.L.

N80-16210*# Southwest Research Inst., San Antonio, Tex.
PREDICTION OF FRAGMENT VELOCITIES AND TRAJECTORIES c37
J. J. Kulesz, L. M. Vargas, and P. K. Moseley *In* Shock and Vibration Inform. Center The Shock and Vibration Bull., Pt. 1 Sep. 1979 p 171-187 refs (For primary document see N80-16198 07-31)
(Contract NAS3-20497)
Avail: NTIS HC A09/MF A01 CSCL 20K

Analytical techniques are described which predict: (1) the velocities of two unequal fragments from bursting cylindrical pressure vessels; (2) the velocity and range of portions of vessels containing a fluid which, when the vessel ruptures, causes the fragment to accelerate as the fluid changes from the liquid to the gaseous phase; and (3) the ranges of fragments subjected to drag and lift forces during flight. Numerous computer runs were made with various initial conditions in an effort to generalize the results for maximum range in plots of dimensionless range versus dimensionless velocity. R.E.S.

32 COMMUNICATIONS

Includes land and global communications; communications theory; and optical communications.

For related information see also *04 Aircraft Communications and Navigation* and *17 Spacecraft Communications, Command and Tracking.*

N80-32610*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A QUANTITATIVE ANALYSIS OF INTER-ISLAND TELEPHONY TRAFFIC IN THE PACIFIC BASIN REGION (PBR)
David D. Evans and Clifford H. Arth Washington Sep. 1980 20 p refs
(NASA-TM-81587; E-566) Avail: NTIS HC A02/MF A01 CSCL 17B

As part of NASA's continuing assessment of future communication satellite requirements, a study was conducted to quantitatively scope current and future telecommunication traffic demand in the South Pacific Archipelagos. This demand was then converted to equivalent satellite transponder capacities. Only inter-island telephony traffic for the Pacific Basin Region was included. The results show that if all this traffic were carried by a satellite system one-third of a satellite transponder would be needed to satisfy the base-year (1976-1977) requirement and about two-thirds of a satellite transponder would be needed to satisfy the forecasted 1985 requirement. Author

A80-25916 * # **NASA advanced communications systems analysis.** J. J. Ward (NASA, Lewis Research Center, Cleveland, Ohio). In: ICC '79; International Conference on Communications, Boston, Mass., June 10-14, 1979, Conference Record. Volume 1. (A80-25901 09-32) Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979, p. 15.2.1-15.2.5.

The purpose of the paper is to investigate and study in-depth market and system analysis for improving satellite communications. The analyses fall into two categories: the broad, scoping efforts intended to screen potential candidates and studies to develop viable operational system configurations and identify critical technology elements. To illustrate the approach, the results of 30/20 GHz study efforts which have been under way in the past few years are reviewed in detail. C.F.W.

A80-25917 * # **30/20 GHz wideband technology verification program.** D. L. Wright (NASA, Lewis Research Center, Cleveland, Ohio). In: ICC '79; International Conference on Communications, Boston, Mass., June 10-14, 1979, Conference Record. Volume 1. (A80-25901 09-32) Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979, p 15.3.1-15.3.4.

This paper discusses various aspects of the 30/20 GHz wideband technology verification activities of NASA. The discussion considers the objectives, approach, system requirements, possible experiment configuration and payload, and the supporting research and technology elements. (Author)

A80-25920 * # **NASA communications technology research and development.** A. F. Durham (NASA, Goddard Space Flight Center, Greenbelt, Md.) and N. Stankiewicz (NASA, Lewis Research Center, Cleveland, Ohio). In: ICC '79; International Conference on Communications, Boston, Mass., June 10-14, 1979, Conference Record. Volume 1. (A80-25901 09-32) Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979, p. 15.6.1-15.6.5.

The development of a 1978 NASA study to identify technology requirements is surveyed, and its principal conclusions, recommendations, and priorities are summarized. In addition, antenna, traveling wave tube, and solid state amplifier developments representing selected items from the current communications technology development programs at the NASA Lewis Research and Goddard Space Flight Centers are described. M.E.P.

A80-26795 * # **National Aeronautics and Space Administration plans for space communication technology.** R. E. Alexovich (NASA, Lewis Research Center, Cleveland, Ohio). In: EASCON '79; Electronics and Aerospace Systems Conference, Arlington, Va., October 9-11, 1979, Conference Record. Volume 2. (A80-26776 09-32) New York, Institute of Electrical and Electronics Engineers, Inc., 1979, p. 273-278. 10 refs.

A program plan is presented for a space communications application utilizing the 30/20 GHz frequency bands (30 GHz uplink and 20 GHz downlink). Results of market demand studies and spacecraft systems studies which significantly affect the supporting research and technology program are also presented, along with the scheduled activities of the program plan. C.F.W.

A80-28712 * **NASA's program in communication satellites.** J. N. Sivo (NASA, Lewis Research Center, Communications and Applications Div., Cleveland, Ohio). In: Space Shuttle: Dawn of an era; Proceedings of the Twenty-sixth Annual Conference, Los Angeles, Calif., October 29-November 1, 1979. Part 2. (A80-28696 10-16) San Diego, Calif., American Astronautical Society; Univelt, Inc., 1980, p. 659-675. (AAS 79-247)

It is noted that NASA is currently proceeding with a revitalized R&D program aimed at the development and demonstration of advanced communication satellite system concepts and the related enabling technologies. The paper reviews the important elements of this program thrust, the approach NASA is taking to assure proper involvement of both the system supplier industry and the service supplier industry and the specific technology focus in the near term. Finally, highlights of the current NASA and industry activities related to opening up the 30/20 GHz frequency band for both commercial and military use are presented. M.E.P.

N80-10415*# TRW, Inc., Redondo Beach, Calif. Space Systems Div.
THE 30/20 GHz MIXED USER ARCHITECTURE DEVELOPMENT STUDY Final Report
Oct. 1979 216 p refs
(Contract NAS3-21933)
(NASA-CR-159686) Avail: NTIS HC A10/MF A01 CSCL 17B

A mixed-user system is described which provides cost-effective communications services to a wide range of user terminal classes, ranging from one or two voice channel support in a direct-to-user mode, to multiple 500 mbps trunking channel support. Advanced satellite capabilities are utilized to minimize the cost of small terminals. In a system with thousands of small terminals, this approach results in minimum system cost. Author

N80-10416*# TRW, Inc., Redondo Beach, Calif. Space Systems Div.
THE 30/20 GHz MIXED USER ARCHITECTURE DEVELOPMENT STUDY: EXECUTIVE SUMMARY
Sep. 1979 24 p
(Contract NAS3-21933)
(NASA-CR-159687) Avail: NTIS HC A02/MF A01 CSCL 17B

The baseline 30/30 GHz satellite communication system, designed for cost-effective communications in the years 1990 to 2000, incorporates on-board satellite demodulation and routing of individual 64 kbps digital voice-grade circuits. This level of routing flexibility is necessary to provide efficient communications to the large number of direct-to-user terminals (DTU) projected. The circuit interfacing hardware is distributed among all the DTU and master control stations. The switching circuitry which provides full interconnectivity between 30 to 45 thousand circuits is in the satellite. The DTU terminal cost, perhaps the largest element in the system cost, represents the largest economic value element of the system because it avoids using terrestrial signal distribution and routing and the charges associated with these functions. Satellite baseline design and power requirements for the system are examined. A.R.H.

N80-11277*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
CONCEPTS FOR 18/30 GHz SATELLITE COMMUNICATION SYSTEM, VOLUME 1 Final Report
R. Jorasch, M. Baker, R. Davies, L. Cuccia, and C. Mitchell 1 Nov. 1979 169 p 3 Vol.
(Contract NAS3-21362)
(NASA-CR-159625-Vol-1; WDL-TR8457-Vol-1) Avail: NTIS HC A08/MF A01 CSCL 17B

Concepts for 18/30 GHz satellite communication systems are presented. Major terminal trunking as well as direct-to-user configurations were evaluated. Critical technologies in support of millimeter wave satellite communications were determined. M.M.M.

N80-11278*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
CONCEPTS FOR 18/30 GHz SATELLITE COMMUNICATION SYSTEM, VOLUME 1A: APPENDIX Final Report
R. Jorasch, M. Baker, R. Davies, L. Cuccia, and C. Mitchell 1 Nov. 1979 181 p refs 3 Vol.
(Contract NAS3-21362)
(NASA-CR-159625-Vol-1A; WDL-TR8457-Vol-1A) Avail: NTIS HC A09/MF A01 CSCL 17B

The following are appended: (1) Propagation phenomena and attenuation models; (2) Models and measurements of rainfall patterns in the U.S.; (3) Millimeter wave propagation experiments; (4) Comparison of theory and experiment; (5) A practical rain attenuation model for CONUS; (6) Space diversity; (7) Values of attenuation for selected U.S. cities; and (8) Additional considerations. M.M.M.

N80-11279*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
CONCEPTS FOR 18/30 GHz SATELLITE COMMUNICATION SYSTEM STUDY. EXECUTIVE SUMMARY
M. Baker, R. Davies, L. Cuccia, and C. Mitchell 1 Nov. 1979 36 p 3 Vol.
(Contract NAS3-21362)
(NASA-CR-159680; WDL-TR8457) Avail: NTIS HC A03/MF A01 CSCL 17B

An examination of a multiplicity of interconnected parameters ranging from specific technology details to total system economic costs for satellite communication systems at the 18/30 GHz transmission bands are presented. It was determined that K sub A band systems can incur a small communications outage during very heavy rainfall periods and that reducing the outage to zero would lead to prohibitive system costs. On the other hand, the economics of scale, ie, one spacecraft accommodating 2.5 GHz of bandwidth coupled with multiple beam frequency reuse, leads

N80-12259*# Case Western Reserve Univ., Cleveland, Ohio. Dept. of Electrical Engineering and Applied Physics.
LOW SIDELOBE LEVEL LOW-COST EARTH STATION ANTENNAS FOR THE 12 GHz BROADCASTING SATELLITE SERVICE
R. E. Collin and L. R. Gabel Sep. 1979 117 p refs
(Contract NAS3-21365)
(NASA-CR-159703) Avail: NTIS HC A06/MF A01 CSCL 17B

An experimental investigation of the performance of 1.22 m and 1.83 m diameter paraboloid antennas with an f/D ratio of 0.38 and using a feed developed by Kumar is reported. It is found that sidelobes below 30 dB can be obtained only if the paraboloids are relatively free of surface errors. A theoretical analysis of clam shell distortion shows that this is a limiting factor in achieving low sidelobe levels with many commercially available low cost paraboloids. The use of absorbing pads and small reflecting plates for sidelobe reduction is also considered. Author

N80-12260*# Mitre Corp., Bedford, Mass.
APPLICATION OF ADVANCED ON-BOARD PROCESSING CONCEPTS TO FUTURE SATELLITE COMMUNICATIONS SYSTEMS
J. L. Katz, M. Hoffman, S. L. Kota, J. M. Ruddy, and B. F. White Jun. 1979 406 p refs 2 Vol.
(Contract F19628-79-C-0001; AF Proj. 8680)
(NASA-CR-159682; MTR-3787-Vol-1) Avail: NTIS HC A18/MF A01 CSCL 17B

An initial definition of on-board processing requirements for an advanced satellite communications system to service domestic markets in the 1990's is presented. An exemplar system architecture with both RF on-board switching and demodulation/remodulation baseband processing was used to identify important issues related to system implementation, cost, and technology development. R.C.T.

N80-12261*# Mitre Corp., Bedford, Mass.
APPLICATION OF ADVANCED ON-BOARD PROCESSING CONCEPTS TO FUTURE SATELLITE COMMUNICATIONS SYSTEMS: BIBLIOGRAPHY
R. L. Edelman and J. L. Katz Jun. 1979 109 p 2 Vol.
(Contract F19628-79-C-0001; AF Proj. 8680)
(NASA-CR-159684; MTR-3787-Vol-2) Avail: NTIS HC A06/MF A01 CSCL 17B

Abstracts are presented of a literature survey of reports concerning the application of signal processing concepts. Approximately 300 references are included. R.C.T.

N80-18262*# International Telephone and Telegraph Corp., New York.
THE 30/20 GHz FIXED COMMUNICATIONS SYSTEMS SERVICE DEMAND ASSESSMENT. VOLUME 1: EXECUTIVE SUMMARY
R. B. Gamble, H. R. Seltzer, K. M. Speter, and M. Westheimer Aug. 1979 50 p 3 Vol.
(Contract NAS3-21366)
(NASA-CR-159619) Avail: NTIS HC A03/MF A01 CSCL 17B

Demand for telecommunications services is forecasted for the period 1980-2000, with particular reference to that portion of the demand associated with satellite communications. Overall demand for telecommunications is predicted to increase by a factor of five over the period studied and the satellite portion of demand will increase even more rapidly. Traffic demand is separately estimated for voice, video, and data services and is also described as a function of distance traveled and city size. The satellite component of projected demand is compared with the capacity available in the C and Ku satellite bands and it is projected that new satellite technology and the implementation of Ka band transmission will be needed in the decade of the 1990's. Author

N80-18263*# International Telephone and Telegraph Corp., New York.
THE 30/20 GHz FIXED COMMUNICATIONS SYSTEMS SERVICE DEMAND ASSESSMENT. VOLUME 2: MAIN REPORT
R. B. Gamble, H. R. Seltzer, K. M. Speter, and M. Westheimer Aug. 1979 309 p refs 3 Vol.
(Contract NAS3-21366)
(NASA-CR-159620) Avail: NTIS HC A14/MF A01 CSCL 17B

A forecast of demand for telecommunications services through the year 2000 is presented with particular reference to demand for satellite communications. Estimates of demand are provided for voice, video, and data services and for various subcategories of these services. The results are converted to a common digital measure in terms of terabits per year and aggregated to obtain total demand projections. J.M.S.

N80-18264*# International Telephone and Telegraph Corp., New York.
THE 30/20 GHz FIXED COMMUNICATIONS SYSTEMS SERVICE DEMAND ASSESSMENT. VOLUME 3: ANNEX
R. B. Gamble, H. R. Seltzer, K. M. Speter, and M. Westheimer Aug. 1979 63 p 3 Vol.
(Contract NAS3-21366)
(NASA-CR-159621) Avail: NTIS HC A04/MF A01 CSCL 17B

A review of studies forecasting the communication market in the United States is given. The applicability of these forecasts to assessment of demand for the 30/20 GHz fixed communications system is analyzed. Costs for the 30/20 satellite trunking systems are presented and compared with the cost of terrestrial communications. J.M.S.

N80-22547*# Western Union Telegraph Co., Upper Saddle River, N.J.
THE 18/30 GHz FIXED COMMUNICATIONS SYSTEM SERVICE DEMAND ASSESSMENT. VOLUME 1: EXECUTIVE SUMMARY
T. Gabriszeski, P. Reiner, J. Rogers, and W. Terbo Jun. 1979 32 p 3 Vol.
(Contract NAS3-21359)
(NASA-CR-159546) Avail: NTIS HC A03/MF A01 CSCL 17D

The total demand for voice, video, and data communications services, and satellite transmission services at the 4/6 GHz, 12/14 GHz, and 18/30 GHz frequencies is discussed. Major study objectives, overall methodology, results, and general observations about a satellite systems market characteristics and trends are summarized. M.G.

N80-22548*# Western Union Telegraph Co., Upper Saddle River, N.J.
THE 18/30 GHz FIXED COMMUNICATIONS SYSTEM SERVICE DEMAND ASSESSMENT. VOLUME 2: MAIN TEXT
T. Gabriszeski, P. Reiner, J. Rogers, and W. Terbo Jun. 1979 328 p refs 3 Vol.
(Contract NAS3-21359)
(NASA-CR-159547) Avail: NTIS HC A15/MF A01 CSCL 17B

The total demand for communications services, and satellite transmission services at the 4/6 GHz, 12/14 GHz, and 18/30 GHz frequencies is assessed. The services are voice, video, and data services. Traffic demand, by service, is distributed by geographical regions, population density, and distance between serving points. Further distribution of traffic is made among four major end user groups: business, government, institutions and private individuals. A traffic demand analysis is performed on a typical metropolitan city to examine service distribution trends. The projected cost of C and Ku band satellite systems are compared on an individual service basis to projected terrestrial rates. Separation of traffic between transmission systems, including 18/30 GHz systems, is based on cost, user, and technical considerations. M.G.

N80-22549*# Western Union Telegraph Co., Upper Saddle River, N.J.
THE 30/20 GHz FIXED COMMUNICATIONS SYSTEMS SERVICE DEMAND ASSESSMENT. VOLUME 3: APPENDICES
T. Gabriszeski, P. Reiner, J. Rogers, and W. Terbo Jun. 1979 200 p refs 3 Vol.
(Contract NAS3-21359)
(NASA-CR-159548) Avail: NTIS HC A09/MF A01 CSCL 17B

The market analysis of voice, video, and data 18/30 GHz communications systems services and satellite transmission services is discussed. Detail calculations, computer displays of traffic, survey questionnaires, and detailed service forecasts are presented. M.G.

N80-24614*# Mitre Corp., Bedford, Mass.
ON-BOARD PROCESSING CONCEPTS FOR FUTURE SATELLITE COMMUNICATIONS SYSTEMS
William T. Brandon, ed. and Brian E. White, ed. May 1980 39 p refs
(Contract F19628-80-C-0001)
(NASA-CR-159683; MTR-3943) Avail: NTIS HC A03/MF A01 CSCL 17B

The initial definition of on-board processing for an advanced satellite communications system to service domestic markets in the 1990's is discussed. An exemplar system with both RF on-board switching and demodulation/remodulation baseband processing is used to identify important issues related to system implementation, cost, and technology development. Analyses of spectrum-efficient modulation, coding, and system control techniques are summarized. Implementations for an RF switch and baseband processor are described. Among the major conclusions listed is the need for high gain satellites capable of handling tens of simultaneous beams for the efficient reuse of the 2.5 GHz 30/20 frequency band. Several scanning beams are recommended in addition to the fixed beams. Low power solid state 20 GHz GaAs FET power amplifiers in the 5W range and a general purpose digital baseband processor with gigahertz logic speeds and megabits of memory are also recommended. A.R.H.

A80-29544 * # **An advanced mixed user domestic satellite system architecture.** H. G. Raymond (TRW Systems Engineering Laboratory, Redondo Beach, Calif.) and W. M. Holmes, Jr. (TRW Defense and Space Systems Group, Redondo Beach, Calif.). In: Communications Satellite Systems Conference, 8th, Orlando, Fla., April 20-24, 1980, Technical Papers. (A80-29526 11-32) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 148-153. Contract No. NAS3-21933. (AIAA 80-0494)

A domestic satellite system architecture that can efficiently and economically accommodate a wide variety of disparate user classes is described and a baseline system configuration identified. With such a technique, both the efficiency of TDMA operation and the operational terminal flexibility of FDMA can be simultaneously achieved. V.T.

A80-29574 * # **Packet communications in satellites with multiple-beam antennas and signal processing.** R. Davies, F. Chethik, and M. Penick (Ford Aerospace and Communications Corp., Palo Alto, Calif.). In: Communications Satellite Systems Conference, 8th, Orlando, Fla., April 20-24, 1980, Technical Papers. (A80-29526 11-32) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 378-385. Contract No. NAS3-21364. (AIAA 80-0537)

A communication satellite with a multiple-beam antenna and onboard signal processing is considered for use in a 'message-switched' data relay system. The signal processor may incorporate demodulation, routing, storage, and remodulation of the data. A system user model is established and key functional elements for the signal processing are identified. With the throughput and delay requirements as the controlled variables, the hardware complexity, operational discipline, occupied bandwidth, and overall user end-to-end cost are estimated for (1) random-access packet switching; and (2) reservation-access packet switching. Other aspects of this network (eg, the adaptability to channel switched traffic requirements) are examined. For the given requirements and constraints, the reservation system appears to be the most attractive protocol. (Author)

A80-29588 * # **Ka-band, multibeam, contiguous coverage satellite antenna for the USA.** P. Foldes (General Electric Co., Space Div., Philadelphia, Pa.) In: Communications Satellite Systems Conference, 8th, Orlando, Fla., April 20-24, 1980, Technical Papers. (A80-29526 11-32) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 490-499. Contract No. NAS3-21745. (AIAA 80-0557)

The behavior of a multibeam antenna is determined by three major characteristics: beam topology, realizable radiation characteristics, and realizable beamforming network architecture. Eight canonical topology plans have been developed and analyzed: angular separation between identical frequency cells, angular separation between orthogonally polarized identical frequency cells, number and configuration of cells forming coverage areas, and crossover level between nonidentical frequency band cells. A general topology plan is developed for the continental United States for 100-deg W synchronous satellite longitude. B.J.

A80-29605 * # **Multigigabit satellite on-board signal processing.** W. M. Holmes, Jr. (TRW, Inc., Space Systems Div., Redondo Beach, Calif.). In: Communications Satellite Systems Conference, 8th, Orlando, Fla., April 20-24, 1980, Technical Papers. (A80-29526 11-32) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 623-626. Contract No. NAS3-21933. (AIAA 80-0583)

The satellite communication system described provides communications for very small and very large (trunking) users. Independent combinations of FDMA and TDMA are used in the uplink and downlink designs to minimize terminal costs. Signal routing for small users is accomplished by a digital store-and-forward technique which greatly simplifies the terminal receiver, compared to satellite-switched TDMA. Different processing techniques are used for very high data rate users, but complete interconnectivity between all users is maintained. This avoids double-hop routing with excessive transmission delays. (Author)

A80-52479 * **System analysis for millimeter-wave communication satellites.** L. D. Holland, N. B. Hilsen, J. J. Gallagher (Georgia Institute of Technology, Atlanta, Ga.), and G. Stevens (NASA, Lewis Research Center, Cleveland, Ohio). *Microwave Journal,* vol. 23, Oct. 1980, p. 43-45, 93. 10 refs.

Research and development needs for millimeter-wave space communication systems are presented. Assumed propagation fade statistics are investigated along with high data rate diversity link and storage. The development of reliable ferrite switches, and high performance receivers and transmitters is discussed, in addition to improved tolerance of dish and lens fabrication for the antennas. The typical cost for using a simplex voice channel via a high capacity 40/50 GHz satellite is presented. R.C.

33 ELECTRONICS AND ELECTRICAL ENGINEERING

Includes test equipment and maintainability; components, e.g., tunnel diodes and transistors; microminiaturization; and integrated circuitry.

For related information see also *60 Computer Operations and Hardware* and *76 Solid-State Physics.*

N80-11327*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HEAT PIPE COOLING OF POWER PROCESSING MAGNETICS
Irving G. Hansen and Morris Chester (TRW Corp., Redondo Beach, Calif.) 1979 10 p refs Presented at the 14th Intern. Conf. on Elec. Propulsion, Princeton, N. J., 30 Oct. - 2 Nov. 1979; Sponsored by AIAA and Deut. Ges. fur Luft- und Raumfahrt
(NASA-TM-79270; E-223) Avail: NTIS HC A02/MF A01 CSCL 09C

A heat pipe cooled transformer and input filter were developed for the 2.4 kW beam supply of a 30 cm ion thruster system. This development yielded a mass reduction of 40% (1.76 kg)

N80-13361*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF 22.4-kW NONLAMINATED-FRAME dc SERIES MOTOR WITH CHOPPER CONTROLLER Final Report
John R. Schwab Sep. 1979 25 p refs
(Contract EC-77-A-31-1044)
(NASA-TM-79252; DOE/NASA/1044-79/4; E-163) Avail: NTIS HC A02/MF A01 CSCL 09C

Performance data obtained through experimental testing of a 22.4 kW traction motor using two types of excitation are presented. Ripple free dc from a motor-generator set for baseline data and pulse width modulated dc as supplied by a battery pack and chopper controller were used for excitation. For the same average values of input voltage and current, the motor power output was independent of the type of excitation. However, at the same speeds, the motor efficiency at low power output (corresponding to low duty cycle of the controller) was 5 to 10 percentage points lower on chopped dc than on ripple free dc. The chopped dc locked rotor torque was approximately 1 to 3 percent greater than the ripple free dc torque for the same average current. J.M.S.

N80-18300*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID METAL SLIP RING Patent Application
Frank D. Berkopec, Robert R. Lovell, and David H. Culp, inventors (to NASA) Filed 21 Dec. 1979 11 p
(NASA-Case-LEW-12277-3; US-Patent-Appl-SN-106190) Avail: NTIS HC A02/MF A01 CSCL 09A

The liquid metal slip ring described comprises a rotor in the form of a range about an axis and a stator, the rotor being rotatable relative to the stator. The rotor has a channel in which the liquid metal is retained during operation by surface tension. The stator comprises a brush or probe which is partially immersed in the metal in the channel and is bidirectionally symmmetrical so that whichever direction the rotor turns the probe presents the same physical resistance and affords the same electrical conductivity as a connection between the probe and the rotor. Author

N80-18302*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THERMIONIC CATHODE LIFE TEST STUDIES
Ralph Forman and Paul Elmer (Watkins-Johnson, Palo Alto, Calif.) 1980 11 p refs Proposed for presentation at the Tri-Services Cathode Workshop, New York, 15-17 Apr. 1980, sponsored by Dept. of the Air Force
(NASA-TM-81441; E-317) Avail: NTIS HC A02/MF A01 CSCL 09A

An update on the life testing of commerical, high current density impregnated tungsten cathodes is presented. The B-type cathodes, operated at a current density of 2 A/cm2 and a cathode temperature of 1100 C have now been run satisfactorily for more than four years. The M-cathode, at the same current density but at an operating temperature of only 1010 C, have been tested for more than three years. The M-cathodes show no degradation in current over their present operating life whereas the current from the B-cathodes degrade about 6 percent after four years of operation. R.E.S.

N80-19425*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COUPLED CAVITY TRAVELING WAVE TUBE WITH VELOCITY TAPERING Patent Application
Denis J. Connolly, inventor (to NASA) Filed 20 Feb. 1980 16 p
(NASA-Case-LEW-12296-1; US-Patent-Appl-SN-122966) Avail: NTIS HC A02/MF A01 CSCL 09A

A coupled cavity traveling wave tube is described which has a velocity taper, i.e., gradual velocity reduction, which affords beam wave resynchronization and thereby enhances efficiency. The required wave velocity reduction is achieved by reducing the resonant frequencies of the individual resonant cavities as a function of the distance from the electron gun through changes in the internal cavity dimensions. The required changes in cavity dimensions are accomplished, for example, by gradually increasing the cavity radius or decreasing the gap length from cavity to cavity. NASA

N80-20487* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CATALYST SURFACES FOR THE CHROMOUS/CHROMIC REDOX COUPLE Patent
Jose D. Giner (Giner, Inc.) and Kathleen J. Cahill, inventor (to NASA) (Giner, Inc.) Issued 11 Mar. 1980 8 p Filed 29 Nov. 1978 Supersedes N79-14538 (17 - 05, p 0618) Sponsored by NASA
(NASA-Case-LEW-13148-1; US-Patent-4,192,910; US-Patent-Appl-SN-964754; US-Patent-Class-429-101; US-Patent-Class-429-105; US-Patent-Class-429-107; US-Patent-Class-429-109) Avail: US Patent and Trademark Office CSCL 09A

An electricity producing cell of the reduction-oxidation (REDOX) type is described. The cell is divided into two compartments by a membrane, each compartment containing a solid inert electrode. A ferrous/ferric couple in a chloride solution serves as a cathode fluid which is circulated through one of the compartments to produce a positive electric potential disposed therein. A chromic/chromous couple in a chloride solution serves as an anode fluid which is circulated through the second compartment to produce a negative potential on an electrode disposed therein. The electrode is an electrically conductive, inert material plated with copper, silver or gold. A thin layer of lead plates onto the copper, silver or gold layer when the cell is being charged, the lead ions being available from lead chloride which was added to the anode fluid. If the REDOX cell is then discharged, the current flows between the electrodes causing the lead to deplate from the negative electrode and the metal coating on the electrode will act as a catalyst to cause increased current density.

Official Gazette of the U.S. Patent and Trademark Office

N80-21669*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MULTISTAGE DEPRESSED COLLECTOR WITH EFFICIENCY OF 90 TO 94 PERCENT FOR OPERATION OF A DUAL-MODE TRAVELING WAVE TUBE IN THE LINEAR REGION
Peter Ramins and Thomas A. Fox Washington Apr. 1980 16 p refs

(NASA-TP-1670; E-9875) Avail: NTIS HC A02/MF A01 CSCL 09A

An axisymmetric, multistage, depressed collector of fixed geometric design was evaluated in conjunction with an octave bandwidth, dual mode traveling wave tube (TWT). The TWT was operated over a wide range of conditions to simulate different applications. The collector performance was optimized (within the constraint of fixed geometric design) over the range of TWT operating conditions covered. For operation of the TWT in the linear, low distortion range, 90 percent and greater collector efficiencies were obtained leading to TWT overall efficiencies of 20 to 35 percent, as compared with 2 to 5 percent with an undepressed collector. With collectors of this efficiency and minimized beam interception losses, it becomes practical to design dual mode TWT's such that the low mode can represent operation well below saturation. Consequently, the required pulse up in beam current can be reduced or eliminated, and this mitigates beam control and dual mode TWT circuit design problems. For operation of the dual mode TWT at saturation, average collector efficiencies in excess of 85 percent were obtained for both the low and high modes across an octave bandwidth, leading to a three to fourfold increase in the TWT overall efficiency. Author

N80-22598*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IMPROVED TRAVELING WAVE TUBES

Erik Buck 1980 15 p refs Presented at Western Region Electronic Warfare Tech. Meeting, White Sands Missile, Range, N. Mex., 21-24 Apr. 1980; sponsored by Assoc. of Old Crows (NASA-TM-81479; E-415) Avail: NTIS HC A02/MF A01 CSCL 09A

After a brief description of how a typical TWT works, multi-stage depressed collectors (MDC) are discussed. A quick method for computing the expected efficiency of a well engineered TWT is outlined to aid in estimating power supply needs. Applications of improved TWTs and a new power supply are suggested. E.D.K.

A80-13902 * // **Analytical prediction and experimental verification of TWT and depressed collector performance using multidimensional computer programs.** J. A. Dayton, Jr. H. G. Kosmahl, P. Ramins, and N. Stankiewicz (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Electron Devices,* vol. ED-26, Oct. 1979, p. 1589-1598. 14 refs.

A80-13903 * // **A matrix solution for the simulation of magnetic fields with ideal current loops.** N. Stankiewicz (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Electron Devices,* vol. ED-26, Oct. 1979, p. 1598-1601. 5 refs.

A matrix formulation is presented for describing axisymmetric magnetic field data with ideal current loops. A computer program written in APL is used to invert the matrix and hence to solve for the coil strengths which are used to represent the field data. Examples are given of the coil representation for (1) measured magnetic data, (2) refocusing fields, and (3) PPM focusing fields. (Author)

A80-13909 * // **90- to 93-percent efficient collector for operation of a dual-mode traveling-wave tube in the linear region.** P. Ramins and T. A. Fox (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Electron Devices,* vol. ED-26, Oct. 1979, p. 1662-1664. 8 refs.

An axisymmetric multistage depressed collector was evaluated in conjunction with a dual-mode TWT. Collector performance optimizations for the TWT operation in the linear range were stressed. Measured collector efficiencies in excess of 90 percent led to dramatic improvements in TWT overall efficiency. (Author)

A80-14720 * **Elastohydrodynamic film thickness measurements of artificially-produced nonsmooth surfaces.** C. Cusano (Illinois, University, Urbana, Ill.) and L. D. Wedeven (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Dayton, Ohio, Oct. 16-18, 1979, ASLE Preprint 79-LC-1A-3,* 13 p. 19 refs.

Optical interferometry is used to measure the elastohydrodynamic (EHD) film thickness associated with artificially produced, nonsmooth surfaces. The nonsmooth surfaces are produced by modifying the surfaces of highly-polished balls with irregularities in the form of multiple grooves and dents. By closely spacing these irregularities, it is possible not only to produce depressions on the surface of the balls but also to generate pseudo asperities. The average roughness wavelength of this artificially-produced, nonsmooth surface approximates the average fundamental roughness wavelength found on surfaces of some mechanical elements operating under concentrated contact. By comparing the measured film thickness profiles to the stylus traces of the irregularities, it is possible to observe the local deformations associated with micro-EHD pressure generation. In both pure rolling and pure sliding conditions, the artificially-produced 'asperities' are deformed and complete separation exists between them and the mating surface. Such findings demonstrate the importance of local surface topography and resulting micro-EHD effects on the film thickness between rough surfaces in concentrated contact. In addition, sliding data are presented which demonstrate a severe constriction, caused by the irregularities, at the exit of the Hertzian region. (Author)

A80-18232 * // **Two-dimensional representations of axisymmetric fields for computer calculations.** N. Stankiewicz (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Electron Devices,* vol. ED-26, Nov. 1979, p. 1790-1795.

An accurate representation of axisymmetric fields has been devised by extending the method of ideal current loops to off-axis fields. It is assumed that the data to be simulated are available through measurements or through a solution of a boundary value problem. The method provides an algebraic expression for the fields throughout a two-dimensional region of interest and eliminates the need for the axial expansion formula in approximating off-axis fields. The use of Gaussian and other functions as alternatives to the coil function is proposed. Examples of the technique in simulating a periodic permanent magnet (PPM) focusing field are presented and compared with a Fourier analysis of the problem. (Author)

A80-31759 * // **How to quickly predict the overall TWT and the multistage depressed collector efficiency.** H. G. Kosmahl (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Electron Devices,* vol. ED-27, Mar. 1980, p. 526-529. 6 refs.

The study deals with an empirical, simple formula extracted from a three-dimensional helical-TWT computer program that expresses the lowest energy in a spent beam in terms of beam perveance and electronic efficiency. The formula has a general validity down to 4 - 5 dB below saturation and gives 1 - delta V/V with less than 20% error down to 10 dB below saturation. V.T.

A80-44235 * # **Improved traveling wave tubes.** E. Buck (NASA, Lewis Research Center, Cleveland, Ohio). *Association of Old Crows, Western Region Electronic Warfare Technical Meeting, White Sands Missile Range, N. Mex., Apr. 21-24, 1980, Paper.* 13 p. 7 refs.

Techniques, pioneered by NASA, which will allow substantial improvements in traveling wave tube (TWT) amplifier efficiency, are described. It is shown that using design techniques developed at the Lewis Research Center, it is possible to approximately double the efficiency of the critical amplifier TWT. Attention is given to a quick method of computing the expected improvement to an ECM TWT. The benefits of such improvements such as less input power, a smaller and lighter power supply, and easier cooling are surveyed, and it noted that it is now possible to build efficient TWT's which rather than operating at saturation, can be very linear amplifiers. Finally, a new approach to power supplies is also covered. M.E.P.

A80-45122 * **Life test studies on tungsten impregnated cathodes.** R. Forman (NASA, Lewis Research Center, Cleveland, Ohio) and P. Elmer (Watkins-Johnson Co., Palo-Alto, Calif.). *IEEE Transactions on Electron Devices,* vol. ED-27, July 1980, p. 1309, 1310.

NASA-Lewis Research Center has conducted an ongoing life test program on commercial impregnated tungsten cathodes since 1971. This brief is an update of the information as of December 1979. B-type cathodes, operated at 1100 C have been run in simulated microwave tubes at 2 A/sq cm for more than four years with about 6-percent degradation in current at a constant reference anode voltage. M-type cathodes have been operated for 30,000 h at a cathode temperature of 1010 C and 2 A/sq cm with no degradation in current as a constant reference anode voltage. (Author)

N80-11328*# Hughes Research Labs., Malibu, Calif.
SOLID-STATE X-BAND COMBINER STUDY Final Report
O. Pitzalis, Jr. and K. J. Russell Aug. 1979 79 p refs Prepared for JPL
(Contracts NAS7-100; JPL-955223)
(NASA-CR-162432) Avail: NTIS HC A05/MF A01 CSCL 09C

The feasibility of developing solid-state amplifiers at 4 and 10 GHz for application in spacecraft altimeters was studied. Bipolar-transistor, field-effect-transistor, and Impatt-diode amplifier designs based on 1980 solid-state technology are investigated. Several output power levels of the pulsed, low-duty-factor amplifiers are considered at each frequency. Proposed transistor and diode amplifier designs are illustrated in block diagrams. Projections of size, weight, and primary power requirements are given for each design. R.C.T.

N80-13362*# TRW Defense and Space Systems Group, Redondo Beach, Calif. Power Conversion Electronics Dept.
HEAT PIPE COOLED POWER MAGNETICS Final Report
M. S. Chester Dec. 1979 176 p Revised
(NASA-CR-159659; TRW-33572-6001-RU-00) Avail: NTIS HC A09/MF A01 CSCL 09A

A high frequency, high power, low specific weight (0.57 kg/kW) transformer developed for space use was redesigned with heat pipe cooling allowing both a reduction in weight and a lower internal temperature rise. The specific weight of the heat pipe cooled transformer was reduced to 0.4 kg/kW and the highest winding temperature rise was reduced from 40 C to 20 C in spite of 10 watts additional loss. The design loss/weight tradeoff was 18 W/kg. Additionally, allowing the same 40 C winding temperature rise as in the original design, the KVA rating is increased to 4.2 KVA, demonstrating a specific weight of 0.28 kg/kW with the internal loss increased by 50W. This space environment tested heat pipe cooled design performed as well electrically as the original conventional design, thus demonstrating the advantages of heat pipes integrated into a high power, high voltage magnetic. Another heat pipe cooled magnetic, a 3.7 kW, 20A input filter inductor was designed, developed, built, tested, and described. The heat pipe cooled magnetics are designed to be Earth operated in any orientation. Author

N80-24560*# Three E Vehicles, San Diego, Calif.
THE PERFORMANCE AND EFFICIENCY OF FOUR MOTOR/CONTROLLER/BATTERY SYSTEMS FOR THE SIMPLER ELECTRIC VEHICLES Final Report
Paul R. Shipps May 1980 88 p refs
(Contracts DEN3-130; EC-77-A-31-1044)
(NASA-CR-159776; DOE/NASA/0130-80/1) Avail: NTIS HC A05/MF A01 CSCL 09C

A test and analysis program performed on four complete propulsion systems for an urban electric vehicle (EV) is described and results given. A dc series motor and a permanent magnet (PM) motor were tested, each powered by an EV battery pack and controlled by (1) a series/parallel voltage-switching (V-switch) system; and (2) a system using a pulse width modulation, 400 Hz transistorized chopper. Dynamometer tests were first performed, followed by eV performance predictions and data correlating road tests. During dynamometer tests using chopper control; current, voltage, and power were measured on both the battery and motor sides of the chopper, using three types of instrumentation. Conventional dc instruments provided adequate accuracy for eV power and energy measurements, when used on the battery side of the controller. When using the chopper controller, the addition of a small choke inductor improved system efficiency in the lower duty cycle range (some 8% increase at 50% duty cycle) with both types of motors. Overall system efficiency rankings during road tests were: (1) series motor with V-switch; (2) PM motor with V-switch; (3) series motor with chopper; and (4) PM motor with chopper. Chopper control of the eV was smoother and required less driver skill than V-switch control. M.G.

A80-28167 * **An adaptive-control switching buck regulator - Implementation, analysis, and design.** F. C. Lee (Virginia Polytechnic Institute and State University, Blacksburg, Va.) and Y. Yu (TRW Defense and Space Systems Group, Redondo Beach, Calif.). *IEEE Transactions on Aerospace and Electronic Systems,* vol. AES-16, Jan. 1980, p. 84-99. 13 refs. Contracts No. NAS3-20102; No. NAS3-21051.

Describing-function techniques and averaging methods have been employed to characterize a multiloop switching buck regulator by three functional blocks: power stage, analog signal processor, and pulse modulator. The model is employed to explore possible forms of pole-zero cancellation and the adaptive nature of the control to filter parameter changes. Analysis-based design guidelines are provided including a suggested additional RC-compensation loop to optimize regulator performances such as stability, audiosusceptibility, output impedance, and load transient response. (Author)

34 FLUID MECHANICS AND HEAT TRANSFER

Includes boundary layers; hydrodynamics; fluidics; mass transfer; and ablation cooling.

For related information see also *02 Aerodynamics* and *77 Thermodynamics and Statistical Physics*.

N80-11376*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STREAKLINE FLOW VISUALIZATION STUDY OF A HORSESHOE VORTEX IN A LARGE-SCALE, TWO-DIMENSIONAL TURBINE STATOR CASCADE

Raymond E. Gaugler and Louis M. Russell 1979 20 p refs Proposed for presentation at 25th Intern. Gas Turbine Conf. and Products Show, New Orleans, La., 9-13 Mar. 1980; sponsored by ASME

(NASA-TM-79274; E-201) Avail: NTIS HC A02/MF A01 CSCL 20D

Neutrally bouyant helium-filled bubbles were observed as they followed the streamlines in a horseshoe vortex system around the vane leading edge in a large scale, two dimensional, turbine stator cascade. Inlet Reynolds number, based on true chord, ranged between 100,000 to 300,000. Bubbles were introduced into the endwall boundary layer through a slot upstream of the vane leading edge. The paths of the bubbles were recorded photographically as streaklines on 16 mm movie film. Individual frames from the film were selected, and overlayed to show the details of the horseshoe vortex around the leading edge. The transport of the vortex across the passage near the leading edge is clearly seen when compared to the streaks formed by bubbles carried in the main stream. Limiting streamlines on the endwall surface were traced by the flow of oil drops. Author

N80-13403*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MARANGONI BUBBLE MOTION IN ZERO GRAVITY

Robert L. Thompson and Kenneth J. DeWitt (Toledo Univ.) 1979 38 p refs Presented at the 72nd Ann. Meeting of the AICE, San Francisco, 25-29 Nov. 1979

(NASA-TM-79250; E-160) Avail: NTIS HC A03/MF A01 CSCL 20D

It was shown experimentally that the Marangoni phenomenon is a primary mechanism for the movement of a gas bubble in a nonisothermal liquid in a low gravity environment. A mathematical model consisting of the Navier-Stokes and thermal energy equations, together with the appropriate boundary conditions for both media, is presented. Parameter perturbation theory is used to solve this boundary value problem; the expansion parameter is the Marangoni number. The zeroth, first, and second order approximations for the velocity, temperature and pressure distributions in the liquid and in the bubble, and the deformation and terminal velocity of the bubble are determined. Experimental zero gravity data for a nitrogen bubble in ethylene glycol, ethanol, and silicone oil subjected to a linear temperature gradient were obtained using the NASA Lewis zero gravity drop tower. Comparison of the zeroth order analytical results for the bubble terminal velocity showed good agreement with the experimental measurements. The first and second order solutions for the bubble deformation and bubble terminal velocity are valid for liquids having Prandtl numbers on the order of one, but there is a lack of appropriate data to test the theory fully. K.L.

N80-13404*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMBUSTION OF SOLID CARBON RODS IN ZERO AND NORMAL GRAVITY

C. M. Spuckler, F. J. Kohl, R. A. Miller, C. A. Stearns, and K. J. DeWitt (Toledo Univ.) 1979 32 p refs Presented at the 72nd Ann. AICE Meeting, San Francisco, 25-29 Nov. 1979

(NASA-TM-79303; E-255) Avail: NTIS HC A03/MF A01 CSCL 21B

In order to investigate the mechanism of carbon combustion, spectroscopic carbon rods were resistance ignited and burned in an oxygen environment in normal and zero gravity. Direct mass spectrometric sampling was used in the normal gravity tests to obtain concentration profiles of CO2, CO, and O2 as a function of distance from the carbon surface. The experimental concentrations were compared to those predicted by a stagnant film model. Zero gravity droptower tests were conducted in order to assess the effect of convection on the normal gravity combustion process. The ratio of flame diameter to rod diameter as a function of time for oxygen pressures of 5, 10, 15, and 20 psia was obtained for three different diameter rods. It was found that this ratio was inversely proportional to both the oxygen pressure and the rod diameter. K.L.

N80-15361*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAM FOR GENERATING INPUT FOR ANALYSIS OF IMPINGEMENT-COOLED, AXIAL-FLOW TURBINE BLADE

David Rosenbaum Jan. 1980 57 p refs Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, Ohio

(NASA-TP-1603; AVRADCOM-TR-79-34) Avail: NTIS HC A04/MF A01 CSCL 20D

A computer program, TACTGRID, was developed to generate the geometrical input for the TACTI program, a program that calculates transient and steady state temperatures, pressures, and cooling flows in an impingement cooled turbine blade. Using spline curves, the TACTGRID program constructs the blade internal geometry from the previously designed external blade surface and newly selected wall and channel thicknesses. The TACTGRID program generates the TACTI calculational grid, calculates arc length between grid points required by TACTI as input, and prepares the namelist input data set used by TACTI for the blade geometry. In addition, TACTGRID produces a scaled computer plot of each blade slice, detailing the grid and calculational stations, and thus eliminates the need for intermediate drafting. J.M.S.

N80-15364*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTATION OF THREE-DIMENSIONAL FLOW IN TURBOFAN MIXERS AND COMPARISON WITH EXPERIMENTAL DATA

L. A. Povinelli, B. H. Anderson, and W. Gerstenmaier Jan. 1980 12 p refs Presented at the AIAA Aerospace Sciences Meeting, Pasadena, Calif., 14-16 Jan. 1980

(NASA-TM-81410; E-324) Avail: NTIS HC A02/MF A01 CSCL 20D

A three dimensional, viscous computer code was used to calculate the mixing downstream of a typical turbofan mixer geometry. Experimental data obtained using pressure and temperature rakes at the lobe and nozzle exit stations were used to validate the computer results. The relative importance of turbulence in the mixing phenomenon as compared with the streamwise vorticity set up by the secondary flows was determined. The observations suggest that the generation of streamwise vorticity plays a significant role in determining the temperature distribution at the nozzle exit plane. K.L.

N80-15365*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NUMERICAL SIMULATION OF SUPERSONIC INLETS USING A THREE-DIMENSIONAL VISCOUS FLOW ANALYSIS

B. H. Anderson and C. E. Towne Jan. 1980 17 p refs Presented at 18th Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980; sponsored by AIAA

(NASA-TM-81411; E-325) Avail: NTIS HC A02/MF A01 CSCL 20D

A three dimensional fully viscous computer analysis was evaluated to determine its usefulness in the design of supersonic inlets. This procedure takes advantage of physical approximations to limit the high computer time and storage associated with complete Navier-Stokes solutions Computed results are presented for a Mach 3 0 supersonic inlet with bleed and a Mach 7 4 hypersonic inlet Good agreement was obtained between theory and data for both inlets Results of a mesh sensitivity study are also shown K.L.

N80-17397*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EFFECTS OF A CERAMIC COATING ON METAL TEMPERATURES OF AN AIR-COOLED TURBINE VANE

Herbert J. Gladden and Curt H. Liebert Feb 1980 29 p refs

(NASA-TP-1598; E-167) Avail NTIS HC A03/MF A01 CSCL 20D

The metal temperatures of air cooled turbine vanes both uncoated and coated with the NASA thermal barrier system were studied experimentally. Current and advanced gas turbine engine conditions were simulated at reduced temperatures and pressures. Airfoil metal temperatures were significantly reduced, both locally and on the average, by use of the the coating. However, at low gas Reynolds number, the ceramic coating tripped a laminar boundary layer on the suction surface, and the resulting higher heat flux increased the metal temperatures. Simulated coating loss was also investigated and shown to increase local metal temperatures. However, the metal temperatures in the leading edge region remained below those of the uncoated vane tested at similar conditions. Metal temperatures in the trailing edge region exceeded those of the uncoated vane. K.L.

N80-17398*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

VOLUME-ENERGY PARAMETERS AND TURBULENT-FLOW DENSITY FLUCTUATIONS

Robert C. Hendricks Jan. 1980 28 p refs

(NASA-TP-1585; E-127) Avail NTIS HC A03/MF A01 CSCL 20D

Volume-energy relations determined from an equation of state were used to group many sets of heat transfer data for liquids and gases, including the near-critical region. The volume - Gibbs energy parameter grouped these data better than did such other parameters as enthalpy, temperature, or internal energy K.L.

N80-20532*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FACTORS AFFECTING CLEANUP OF EXHAUST GASES FROM A PRESSURIZED, FLUIDIZED-BED COAL COMBUSTOR

R. James Rollbuhler and John A. Kobak Mar. 1980 37 p refs

(NASA-TM-81439; E-382) Avail: NTIS HC A03/MF A01 CSCL 20D

The cleanup of effluent gases from the fluidized-bed combustion of coal is examined. Testing conditions include the type and feed rate of the coal and the sulfur sorbent, the coal-sorbent ratio, the coal-combustion air ratio, the depth of the reactor fluidizing bed, and the technique used to physically remove fly ash from the reactor effluent gases. Tests reveal that the particulate loading matter in the effluent gases is a function not only of the reactor-bed surface gas velocity, but also of the type of coal being burnt and the time the bed is operating. At least 95 percent of the fly ash particules in the effluent gas are removed by using a gas-solids separator under controlled operating conditions. Gaseous pollutants in the effluent (nitrogen and sulfur oxides) are held within the proposed Federal limits by controlling the reactor operating conditions and the type and quantity of sorbent material. M.G.

N80-21706*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SIMILARITY TESTS OF TURBINE VANES, EFFECTS OF CERAMIC THERMAL BARRIER COATINGS

Herbert J. Gladden 1980 14 p refs Proposed for Presentation at 1980 Natl. Heat Transfer Conf., Orlando, Fla., 27-30 Jul. 1980; sponsored by Heat Transfer and Gas Turbine Div. of ASME

(NASA-TM-81473; E-407) Avail: NTIS HC A02/MF A01 CSCL 20D

The role of material thermal conductivity was analyzed for its effect on the thermal performance of air-cooled gas turbine components coated with a ceramic thermal barrier material when tested at reduced temperatures and pressures. It is shown that the thermal performance can be evaluated reliably at reduced gas and coolant conditions; however, thermal conductivity corrections are required for the data at reduced conditions. Corrections for a ceramic thermal barrier coated vane are significantly different than for an uncoated vane. Comparison of uncorrected test data, therefore, would show erroneously that the thermal barrier coating was ineffective. When thermal conductivity corrections are applied to the test data these data are then shown to be representative of engine data and also show that the thermal barrier coating increases the vane cooling effectiveness by 12.5 percent. A.R.H.

N80-24573* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HEAT EXCHANGER AND METHOD OF MAKING Patent

Anthony Fortini and John M. Kazaroff, inventors (to NASA) Issued 29 Apr. 1980 6 p Filed 30 Nov. 1977 Supersedes N79-21313 (17 - 02, p 0164) Div. of US Patent Appl. SN-559846, filed 19 Mar. 1975, US Patent No-4,108,241

(NASA-Case-LEW-12441-2, US-Patent-4,199,937; US-Patent-Appl-SN-856462; US-Patent-Class-60-267; US-Patent-Class-239-127.1; US-Patent-Appl-SN-559846) Avail: US Patent and Trademak Office CSCL 20D

A heat exchange of increased effectiveness is disclosed. A porous metal matrix is disposed in a metal chamber or between walls through which a heat-transfer fluid is directed. The porous metal matrix has internal bonds and is bonded to the chamber in order to remove all thermal contact resistance within the composite structure. Utilization of the invention in a rocket chamber is disclosed as a specific use. Also disclosed is a method of constructing the heat exchanger.

Official Gazette of the U.S. Patent and Trademark Office

N80-24577*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXTENSION OF SIMILARITY TEST PROCEDURES TO COOLED ENGINE COMPONENTS WITH INSULATING CERAMIC COATINGS

Herbert J. Gladden May 1980 16 p refs

(NASA-TP-1615; E-337) Avail: NTIS HC A02/MF A01 CSCL 20D

Material thermal conductivity was analyzed for its effect on the thermal performance of air cooled gas turbine components, both with and without a ceramic thermal-barrier material, tested at reduced temperatures and pressures. The analysis shows that neglecting the material thermal conductivity can contribute significant errors when metal-wall-temperature test data taken on a turbine vane are extrapolated to engine conditions. This error in metal temperature for an uncoated vane is of opposite sign from that for a ceramic-coated vane. A correction technique is developed for both ceramic-coated and uncoated components. Author

N80-27632*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INFLUENCE OF PRESSURE DRIVEN SECONDARY FLOWS ON THE BEHAVIOR OF TURBOFAN FORCED MIXERS

B. Anderson, L. Povinelli, and W. Gerstenmaier Jul. 1980 28 p refs Presented at 16th Joint Prop. Conf., Hartford, Conn., 30 Jun. - 2 Jul. 1980; sponsored by AIAA, ACME, and SAE

(NASA-TM-81541; E-493) Avail: NTIS HC A03/MF A01 CSCL 20C

A finite difference procedure was developed to analyze the three dimensional subsonic turbulent flows in turbofan forced mixer nozzles. The method is based on a decomposition of the velocity field into primary and secondary flow components which are determined by solution of the equations governing primary momentum, secondary vorticity, thermal energy, and continuity. Experimentally, a strong secondary flow pattern was identified which is associated with the radial inflow and outflow characteristics of the core and fan streams and forms a very strong vortex system aligned with the radial interface between the core and fan regions. A procedure was developed to generate a similar generic secondary flow pattern in terms of two constants representing the average radial outflow or inflow in the core and fan streams as a percentage of the local streamwise velocity. This description of the initial secondary flow gave excellent agreement with experimental data. By identifying the nature of large scale secondary flow structure and associating it with characteristic mixer nozzle behavior, it is felt that the cause and effect relationship between lobe design and nozzle performance can be understood. E.D.K.

N80-29623*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TOWARD THE USE OF SIMILARITY THEORY IN TWO-PHASE CHOKED FLOWS
R. C. Hendericks, J. V. Sengers (Maryland Univ., College Park), and R. J. Simoneau 1980 12 p refs Proposed for presentation at Winter Ann. Meeting of the ASME, Chicago 16-21 Nov. 1980
(NASA-TM-81568) Avail: NTIS HC A02/MF A01 CSCL 20D

Comparison of two phase choked flows in normalized coordinates were made between pure components and available data using a reference fluid to compute the thermophysical properties. The results are favorable. Solution of the governing equations for two LNG mixtures show some possible similarities between the normalized choked flows of the two mixtures, but the departures from the pure component loci are significant. Author

N80-29624*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY RESULTS FROM A FOUR-WORKING SPACE, DOUBLE-ACTING PISTON, STIRLING ENGINE CONTROLS MODEL
Carl J. Daniele and Carl F. Lorenzo 1980 17 p refs Presented at the 15th Intersoc. Energy Conversion Eng. Conf., Seattle, 18-22 Aug. 1980
(Contract EC-77-A-31-1040)
(NASA-TM-81569; DOE/NASA/1040-17; E-534) Avail: NTIS HC A02/MF A01 CSCL 20D

A four working space, double acting piston, Stirling engine simulation is being developed for controls studies. The development method is to construct two simulations, one for detailed fluid behavior, and a second model with simple fluid behaviour but containing the four working space aspects and engine inertias, validate these models separately, then upgrade the four working space model by incorporating the detailed fluid behaviour model for all four working spaces. The single working space (SWS) model contains the detailed fluid dynamics. It has seven control volumes in which continuity, energy, and pressure loss effects are simulated. Comparison of the SWS model with experimental data shows reasonable agreement in net power versus speed characteristics for various mean pressure levels in the working space. The four working space (FWS) model was built to observe the behaviour of the whole engine. The drive dynamics and vehicle inertia effects are simulated. To reduce calculation time, only three volumes are used in each working space and the gas temperature are fixed (no energy equation). Comparison of the FWS model predicted power with experimental data shows reasonable agreement. Since all four working spaces are simulated, the unique capabilities of the model are exercised to look at working fluid supply transients, short circuit transients, and piston ring leakage effects. Author

N80-32689*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WIND TUNNEL INVESTIGATION OF THE TITAN FORWARD SKIRT COMPARTMENT VENT FROM A FREE-STREAM MACH NUMBER OF 0.80 TO 1.96
Albert L. Johns Washington Sep. 1980 42 p refs
(NASA-TM-81572; E-541) Avail: NTIS HC A03/MF A01 CSCL 20D

A test was conducted to determine the flow characteristics of the Titan forward skirt compartment vent over a free stream Mach number range of 0.80 to 1.96. The vent was mounted in a flat plate and the plate was flush mounted to the tunnel side wall with coinciding center lines. Air was discharged from a duct, located on the tunnel side wall behind the plate, through a canted aft 30 deg honeycomb vent into the free stream. Data for the analysis of the Titan forward skirt compartment venting during ascent through the atmosphere are provided. Full scale simulated flight hardware, such as the honeycomb vent, duct corrugations and field joint ring were used. Boundary layer thicknesses were used to vary boundary height. The highest vent discharge coefficient for any given Mach number and vent pressure ratio generally occurred at the maximum displacement thickness. With no vent flow the static pressure in the vent region was generally less than the free stream static pressure. With vent flow, the static pressures upstream of the vent increased, and those downstream of the vent decreased. R.K.G.

A80-10030 * # **Some aspects of a free jet phenomena to 105 L/D in a constant area duct.** R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio). *International Institute of Refrigeration, International Congress of Refrigeration, 15th, Venice, Italy, Sept. 23-29, 1979, Paper.* 39 p. 7 refs.

The paper examines major constraints involved in the Borda tube free jet phenomena. Under certain conditions, inlets with a Borda type geometry show sufficiently strong separation effects to permit the working fluid to flow through the duct as if it were a 'free jet'. Mass limiting flow data and associated pressure profiles for tubes with L/D's ranging from 14 to 105 with a Borda type inlet were considered to determine bounds of the 'free jet' phenomena using fluid nitrogen. For a given tube roughness, the limits appear to be one dimensional and dependent only on inlet stagnation conditions. For smooth tubes, the upper L/D boundary is defined by an equation relating reduced pressure to reduced temperature, and the lower boundary represents saturation conditions at the inlet. Similar 'free jet' effects were found for fluid hydrogen indicating that fluid jetting may be common to all fluids. A.T.

A80-10031 * # **Critical mass flux through short Borda type inlets of various cross sections.** R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio) and N. P. Poolos (Lake Ridge Academy, North Ridgeville, Ohio). *International Institute of Refrigeration, International Congress of Refrigeration, 15th, Venice, Italy, Sept. 23-29, 1979, Paper.* 24 p. 10 refs.

Mass flux measurements associated with choked flows through four Borda-type inlet geometries: circular, square, triangular, and rectangular (two-dimensional) and two sharp-edged geometries are discussed for a wide range of inlet stagnation conditions. The results obtained indicate that the mass flux is independent of the inlet cross-section geometry, while it is dependent on the inlet stagnation conditions. The results also suggest that parallel surfaces as found in seals, dampers, bearings, and heat exchanger tubes of rectangular cross section with Borda-type inlet configurations are subject to large forces. It is noted that the reduced mass flux is independent of working fluid. V.T.

A80-10037 * # **Free jet phenomena in a 90 deg-sharp edge inlet geometry.** R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio). *National Bureau of Standards, International Cryogenic Engineering Conference and International Cryogenic Materials Conference, Madison, Wis., Aug. 21-24, 1979, Paper.* 28 p. 9 refs.

The effects of free-jet phenomena, jetting, in a 90-deg-sharp-edge inlet tube are analyzed. Mass-limiting flow data and associated pressure profiles for tubes of 53, 64, 73 and 105 L/D with a 90 deg-sharp-edge or orifice-type inlet are compared to Borda-type inlet data to determine bounds of the free-jet phenomena. For smooth tubes the limits appear to be one-dimensional and dependent only on inlet stagnation conditions. The upper L/D boundary is related by stagnation characteristics and the lower bound appears to be saturation conditions at the inlet. It is noted that similar free-jet effects were found for fluid hydrogen indicating that fluid jetting might be common to all fluids flowing through 90 deg-sharp-edge inlet geometries. V.T.

A80-10038 * # **A reduced volumetric expansion factor plot.** R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio). *National Bureau of Standards, International Cryogenic Engineering Conference and International Cryogenic Materials Conference, Madison, Wis., Aug. 21-24, 1979, Paper.* 27 p. 7 refs.

A reduced volumetric expansion factor plot has been constructed for simple fluids which is suitable for engineering computations in heat transfer. Volumetric expansion factors have been found useful in correlating heat transfer data over a wide range of operating conditions including liquids, gases and the near critical region. (Author)

A80-10039 * # **Application of the principle of similarity fluid mechanics.** R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio) and J. V. Sengers (Maryland, University, College Park, Md.). *International Association for Properties of Steam, International Conference on the Properties of Steam, 9th, Munich, West Germany, Sept. 8-14, 1979, Paper.* 47 p. 90 refs. Grant No. NGR-21-002-344.

Possible applications of the principle of similarity to fluid mechanics is described and illustrated. In correlating thermophysical properties of fluids, the similarity principle transcends the traditional corresponding states principle. In fluid mechanics the similarity principle is useful in correlating flow processes that can be modeled adequately with one independent variable (i.e., one-dimensional flows). In this paper we explore the concept of transforming the conservation equations by combining similarity principles for thermophysical properties with those for fluid flow. We illustrate the usefulness of the procedure by applying such a transformation to calculate two phase critical mass flow through a nozzle. (Author)

A80-14660 * **Evolution of a rotating flow in the vicinity of a surface.** R. G. Deissler (NASA, Lewis Research Center, Fundamental Heat Transfer Branch, Cleveland, Ohio). In: Studies in heat transfer: A Festschrift for E. R. G. Eckert. (A80-14655 03-34) Washington, Hemisphere Publishing Corp.; New York, McGraw-Hill Book Co., 1979, p. 83-93 6 refs.

Evolution of a rotating flow in a body of fluid bounded by a stationary flat surface is discussed. The calculated results show that the radial pressure gradient is substantially reduced in the region close to the surface, so that letting that gradient be independent of distance from the surface would be expected to give only rough or qualitative estimates. However, the reduced rotation near the stationary surface is still large enough to cause an inflow near the surface and to set up a recirculation pattern. The concentration of vorticity by the radial inflow is not great enough to increase the tangential velocities near the center of rotation. V.T.

A80-18638 * # **Coolant tube curvature effects on film cooling as detected by infrared imagery.** S. S. Papell and R. W. Graham (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 2-7, 1979, Paper 79-WA/GT-7.* 5 p. 6 refs. Members, $1.50; nonmembers, $3.00.

Reported herein are comparative thermal film cooling footprints observed by infrared imagery from straight, curved and looped coolant tube geometries. It was hypothesized that the difference in secondary flow and turbulence structure of flow through these three tubes should influence the mixing properties between the coolant and mainstream. The coolant was injected across an adiabatic plate through a hole angled at 30 deg to the surface in line with the free stream flow. The data cover a range of blowing rates from 0.37 to 1.25 (mass flow per unit area of coolant divided by free stream). Average temperature difference between coolant and tunnel air was 25 C. Data comparisons confirmed that coolant tube curvature significantly influences film cooling effectiveness. (Author)

A80-20958 * # **Marangoni bubble motion in zero gravity.** R. L. Thompson (NASA, Lewis Research Center, Cleveland, Ohio) and K. J. De Witt (Toledo, University, Toledo, Ohio). *American Institute of Chemical Engineers, Annual Meeting, 72nd, San Francisco, Calif., Nov. 25-29, 1979, Paper.* 36 p. 10 refs.

It is shown experimentally that the Marangoni phenomenon is a primary mechanism for the movement of a gas bubble in a nonisothermal liquid in a low-gravity environment. In such two-phase flow systems, local variations in bubble surface tension are caused by a temperature gradient in the liquid. Shearing stresses thus generated at the bubble surface lead to convection in both media, as a result of which the bubble begins to move. A mathematical model consisting of the Navier-Stokes equations and the thermal energy equations, along with the appropriate boundary conditions for both media, is proposed. V.P.

A80-20960 * # **Heat pipe cooling of power processing magnetics.** I. G. Hansen (NASA, Lewis Research Center, Cleveland, Ohio) and M. Chester (TRW, Inc., Redondo Beach, Calif.). *Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30 - Nov. 1, 1979, AIAA Paper 79-2082.* 9 p.

The constant demand for increased power and reduced mass has raised the internal temperature of conventionally cooled power magnetics toward the upper limit of acceptability. The conflicting demands of electrical isolation, mechanical integrity, and thermal conductivity preclude significant further advancements using conventional approaches. However, the size and mass of multikilowatt power processing systems may be further reduced by the incorporation of heat pipe cooling directly into the power magnetics. Additionally, by maintaining lower more constant temperatures, the life and reliability of the magnetic devices will be improved. A heat pipe cooled transformer and input filter have been developed for the 2.4 kW beam supply of a 30-cm ion thruster system. This development yielded a mass reduction of 40% (1.76 kg) and lower mean winding temperature (20 C lower). While these improvements are significant, preliminary designs predict even greater benefits to be realized at higher power. This paper presents the design details along with the results of thermal vacuum operation and the component performance in a 3 kW breadboard power processor. (Author)

A80-28419 * # **Effect of temperature on surface noise.** W. Olsen and C. Wasserbauer (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA Journal,* vol. 18, Mar. 1980, p. 339, 340. 8 refs.

An experimental work is discussed whose objective was to obtain data that show the effect of temperature and temperature fluctuations on surface noise. This was accomplished experimentally by immersing a small chord airfoil in the turbulent airstream of a hot jet. The theory and experiment reported by Olsen (1976) provided a guide for designing and validating the hot jet experiment and for interpreting the data. It is shown that increased temperature causes a small decrease in the sound levels; at the same time it causes a shift in the spectra that is smaller but similar to the shift observed with subsonic hot jet noise. S.D.

A80-44228 * # **An alternative approach to the numerical simulation of steady inviscid flow.** G. M. Johnson (NASA, Lewis Research Center, Cleveland, Ohio). *U.S. Air Force, NASA, NSF, and U.S. Navy, International Conference on Numerical Methods in Fluid Dynamics, 7th, Stanford University, Stanford, Calif., June 23-27, 1980, Paper.* 6 p. 9 refs.

A numerical procedure for the efficient simulation of steady inviscid flow is described and its utility is demonstrated. The method is uniformly valid for application in the subsonic, transonic and supersonic flow regimes. It does not rely on the introduction of additional assumptions beyond those necessary to obtain the Euler equations from the Navier-Stokes equations, nor does it make use of a time-asymptotic solution of the unsteady equations of motion. Application of the herein-defined surrogate equation technique allows the formulation of stable, fully-conservative, type-dependent finite difference equations for use in obtaining numerical solutions to systems of first-order partial differential equations, such as the steady-state Euler equations or their various approximations. Computational results are presented for the full Euler equations used to simulate rotational subsonic flow and for the transonic small disturbance equations. For the latter case, a computational efficiency greater than that obtained by means of the standard perturbation potential approach is indicated. (Author)

N80-10460*# Battelle Columbus Labs., Ohio.
SPRAY NOZZLE DESIGNS FOR AGRICULTURAL AVIATION APPLICATIONS Final Report, Oct. 1978 - Sep. 1979
K. W. Lee, A. A. Putnam, J. A. Gieseke, M. N. Golovin, and J. A. Hale 18 Sep. 1979 105 p refs
(Contract NAS3-21581)
(NASA-CR-159702) Avail: NTIS HC A06/MF A01 CSCL 20D

Techniques of generating monodisperse sprays and information concerning chemical liquids used in agricultural aviation are surveyed. The periodic dispersion of liquid jet, the spinning disk method, and ultrasonic atomization are the techniques discussed. Conceptually designed spray nozzles for generating monodisperse sprays are assessed. These are based on the classification of the drops using centrifugal force, on using two opposing liquid laden air jets, and on operating a spinning disk at an overloaded flow. Performance requirements for the designs are described and estimates of the operational characteristics are presented. A.W.H.

N80-14356*# Scientific Research Associates, Inc., Glastonbury, Conn.
DEVELOPMENT OF A THREE-DIMENSIONAL SUPERSONIC INLET FLOW ANALYSIS Final Report
R. C. Buggeln, H. McDonald, R. Levy, and J. P. Kreskovsky Jan. 1980 122 p refs
(Contract NAS3-21003)
(NASA-CR-3218) Avail: NTIS HC A06/MF A01 CSCL 20D

A method for computing three dimensional flow in supersonic inlets is described. An approximate set of governing equations is given for viscous flows which have a primary flow direction. The governing equations are written in general orthogonal coordinates. These equations are modified in the subsonic region of the flow to prevent the phenomenon of branching. Results are presented for the two sample cases: a Mach number equals 2.5 flow in a square duct, and a Mach number equals 3.0 flow in a research jet engine inlet. In the latter case the computed results are compared with the experimental data. A users' manual is included. Author

N80-19450*# FWG Associates, Inc., Tullahoma, Tenn.
MONODISPERSE ATOMIZERS FOR AGRICULTURAL AVIATION APPLICATIONS Final Report
Larry S. Christensen and Sidney L. Steely Feb. 1980 81 p refs
(Contract NAS3-21582)
(NASA-CR-159777) Avail: NTIS HC A05/MF A01 CSCL 20D

Conceptual designs of two monodisperse spray nozzles are described and the rationale used in each design is discussed. The nozzles were designed to eliminate present problems in agricultural aviation applications, such as ineffective plant coverage, drift due to small droplets present in the spray being dispersed, and nonuniform swath coverages. Monodisperse atomization techniques are reviewed and a synopsis of the information obtained concerning agricultural aviation spray applications is presented. A.W.H.

N80-23599*# Sigma Research, Inc., Richland, Wash.
TWO-PHASE WORKING FLUIDS FOR THE TEMPERATURE RANGE OF 50 TO 350 DEG, PHASE 2 Final Report
E. W. Saaski and J. H. Hartl Mar. 1980 57 p refs
(Contract NAS3-21202)
(NASA-CR-159847) Avail: NTIS HC A04/MF A01 CSCL 20D

Several two phase heat transfer fluids were tested in aluminum and carbon steel reflux capsules for over 25,000 hours at temperatures up to 300 C. Several fluids showed very good stability and would be useful for long duration heat transfer applications over the range 100 to 350 C. Instrumentation for the measurement of surface tension and viscosity were constructed for use with heat transfer fluids over the temperature range 0 to 300 C and with pressures from 0 to 10 atmospheres. The surface tension measuring device constructed requires less than a 1.0 cc sample and displays an accuracy of about 5 percent in preliminary tests, while the viscometer constructed for this program requires a 0.05 cc sample and shows an accuracy of about 5 percent in initial tests. E.D.K.

N80-32688*# TRW Defense and Space Systems Group, Redondo Beach, Calif.
DEPRIMING OF ARTERIAL HEAT PIPES: AN INVESTIGATION OF CTS THERMAL EXCURSIONS Final Report, Sept. 1978 - Aug. 1980
D. Antoniuk and D. K. Edwards 20 Aug 1980 214 p refs
(Contract NAS3-21740)
(NASA-CR-165153; TRW-34129-6001-UT-00) Avail: NTIS HC A10/MF A01 CSCL 20D

Four thermal excursions of the Transmitter Experiment Package (TEP) were the result of the depriming of the arteries in all three heat pipes in the Variable Conductance Heat Pipe System which cooled the TEP. The determined cause of the depriming of the heat pipes was the formation of bubbles of the nitrogen/helium control gas mixture in the arteries during the thaw portion of a freeze/thaw cycle of the inactive region of the condenser section of the heat pipe. Conditions such as suction freezeout or heat pipe turn-on, which moved these bubbles into the active region of the heat pipe, contributed to the depriming mechanism. Methods for precluding, or reducing the probability of, this type of failure mechanism in future applications of arterial heat pipes are included. Author

A80-42176 * # **Full-coverage film cooling. I - Comparison of heat transfer data for three injection angles.** M. E. Crawford (MIT, Cambridge, Mass.), W. M. Kays, and R. J. Moffat (Stanford University, Stanford, Calif.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-43.* 6 p. 15 refs. Members, $1.50; nonmembers, $3.00. Contract No. NAS3-14336.

Wind tunnel experiments were carried out at Stanford between 1971 and 1977 to study the heat transfer characteristics of full-coverage film cooled surfaces with three geometries; normal-, 30 deg slant-, and 30 deg x 45 deg compound-angled injection. A flat full-coverage section and downstream recovery section comprised the heat transfer system. The experimental objectives were to determine, for each geometry, the effects on surface heat flux of injection blowing ratio, injection temperature ratio, and upstream initial conditions. Spanwise-averaged Stanton numbers were measured for blowing ratios from 0 to 1.3, and for two values of injection temperature at each blowing ratio. The heat transfer coefficient was defined on the basis of a mainstream-to-wall temperature difference. Initial momentum and enthalpy thickness Reynolds numbers were varied from 500 to about 3000. (Author)

A80-42177 * # **Full-coverage film cooling. II - Heat transfer data and numerical simulation.** M. E. Crawford (MIT, Cambridge, Mass.), W. M. Kays, and R. J. Moffat (Stanford University, Stanford, Calif.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-44.* 7 p. 13 refs. Members, $1.50; nonmembers, $3.00. Contract No. NAS3-14336.

Experimental research into heat transfer from full-coverage film-cooled surfaces with three injection geometries was described in Part I. This part has two objectives. The first is to present a simple numerical procedure for simulation of heat transfer with full-coverage film cooling. The second objective is to present some of the Stanton number data that was used in Part I of the paper. The data chosen for presentation are the low-Reynolds number, heated-starting-length data for the three injection geometries with five-diameter hole spacing. Sample data sets with high blowing ratio and with ten-diameter hole spacing are also presented. The numerical procedure has been successfully applied to the Stanton number data sets. (Author)

35 INSTRUMENTATION AND PHOTOGRAPHY

Includes remote sensors; measuring instruments and gages, detectors, cameras and photographic supplies; and holography

For aerial photography see *43 Earth Resources*. For related information see also *06 Aircraft Instrumentation*, and *19 Spacecraft Instrumentation*.

N80-14374*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TEMPERATURE AND PRESSURE MEASUREMENT TECHNIQUES FOR AN ADVANCED TURBINE TEST FACILITY
Frank G. Pollack and Reeves P. Cochran 1980 12 p refs Proposed for presentation at the Intern. Gas Turbine Conf. and Ann. Fluids Engr. Conf., New Orleans, 9-13 Mar. 1980; sponsored by Am. Soc. Mech. Engr.
(NASA-TM-79278; E-212) Avail: NTIS HC A02/MF A01 CSCL 14B

A high pressure, high-temperature turbine test facility constructed for use in turbine cooling research is described. Several recently developed temperature and pressure measuring techniques are used in this facility. The measurement techniques, their status, previous applications and some results are discussed. Noncontact surface temperature measurements are made by optical methods. Radiation pyrometry principles combined with photoelectric scanning are used for rotating components and infrared photography for stationary components. Contact (direct) temperature and pressure measurements on rotating components are expected to be handled with an 80 channel rotary data package which mounts on and rotates with the turbine shaft at speeds up to 17,500 rpm. The data channels are time-division multiplexed and converted to digital words in the data package. A rotary transformer couples power and digital data to and from the shaft. M.M.M.

N80-17422*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FATIGUE STRENGTH TESTING EMPLOYED FOR EVALUATION AND ACCEPTANCE OF JET-ENGINE INSTRUMENTATION PROBES
Everett C. Armentrout 1980 25 p refs Presented at 25th Ann. Intern. Gas Turbine Conf., New Orleans, 9-13 Mar. 1980; sponsored by ASME
(NASA-TM-81402; E-313) Avail: NTIS HC A02/MF A01 CSCL 14B

The fatigue type testing performed on instrumentation rakes and probes intended for use in the air flow passages of jet engines during full scale engine tests is outlined. A discussion of each type of test performed, the results that may be derived and means of inspection is included. R.E.S.

N80-17423*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OPTICAL SENSORS FOR AERONAUTICS AND SPACE
R. J. Baumbick, J. Alexander (NASA. Johnson Space Center), R. Katz (Naval Avionics Center, Indianapolis, Ind.), and J. Terry (Army Applied Technology Labs., Ft. Eustis, Va.) Jan. 1980 16 p
(NASA-TM-81407; E-321) Avail: NTIS HC A02/MF A01 CSCL 14B

A review of some NASA and DOD programs to develop optical sensors with fiberoptics for instrumentation and control is presented. Fiberoptic systems offer some distinct advantages. Noise immunity is one important asset. Fiberoptic systems do not conduct electricity and therefore can be used in and near areas that contain explosive or flammable materials. One objective of these programs is to produce more reliable sensors and to improve the safety and operating economy of future aircraft and space vehicles. Author

N80-18363*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FIBER OPTIC SENSORS FOR MEASURING ANGULAR POSITION AND ROTATIONAL SPEED
Robert J. Baumbick Mar. 1980 13 p
(NASA-TM-81454; E-381) Avail: NTIS HC A02/MF A01 CSCL 20F

Two optical sensors, a 360 deg rotary encoder and a tachometer, were built for operation with the light source and detectors located remotely from the sensors. The source and detectors were coupled to the passive sensing heads through 3.65 meter fiber optic cables. The rotary encoder and tachometer were subjected to limited environmental testing. They were installed on an air breathing engine during recent altitude tests. Over 100 hours of engine operation were accumulated without any failure of either device. K.L.

N80-24595*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DYNAMIC BEHAVIOR OF A BEAM DRAG-FORCE ANEMOMETER
Gustave C. Fralick Washington May 1980 16 p refs
(NASA-TP-1687; E-340) Avail: NTIS HC A02/MF A01 CSCL 14B

A cantilevered beam with strain gages attached to the fixed ends and the minimax technique were used in an experiment conducted to determine the dynamic behavior of a drag-force anemometer in high frequency, unsteady flow. In steady flow the output of the anemometer is proportional to stream velocity head and flow angle. Fluid mechanics suggests that, in unsteady flow, the output would also be proportional to the rate of change of fluid velocity. It was determined that effects due to the rate of change of fluid velocity are negligible for the probe geometry and frequencies involved. A.R.H.

N80-25635*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTERIZED VIDEO DENSITOMETRY METHOD FOR RAPID ANALYSIS OF INFRARED PHOTOGRAPHIC IMAGES
Ernest Roberts, Jr., Frederick D. Calfo, and Frank G. Pollack Jun. 1980 13 p refs
(NASA-TP-1686; E-354) Avail: NTIS HC A02/MF A01 CSCL 14E

A computerized video densitometry method is described which is approximately 50 times faster than a corresponding manual method of analysis, with no apparent sacrifice of accuracy. The object of the technique is to determine the temperature distribution across a heated surface. Infrared photographs of the heated surfaces provide the raw data. A video based, computer operated image analysis system provides the equipment. Infrared photographic pyrometry using a flat bed microdensitometer forms the basis of the technique. The procedure is illustrated on a thermally cycled aircraft gas turbine blade. A.R.H.

A80-12630 * **Measuring unsteady pressure on rotating compressor blades.** D. R. Englund (NASA, Lewis Research Center, Cleveland, Ohio), H. P. Grant, and G. A. Lanati (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.). In: International Instrumentation Symposium, 25th, Anaheim, Calif., May 7-10, 1979, Proceedings. Part 2. (A80-12601 02-35) Pittsburgh, Pa., Instrument Society of America, 1979, p. 413-426. 7 refs.

The capability for accurate measurement of unsteady pressure on the surface of compressor and fan blades during engine operation was established. Tests were run on miniature semiconductor strain gage pressure transducers mounted in several arrangements. Both surface mountings and recessed flush mountings were tested. Test parameters included mounting arrangement, blade material, temperature, local strain in the blade, acceleration normal to the transducer diaphragm, centripetal acceleration, and pressure. Test results showed no failures of transducers or mountings and indicated an uncertainty of unsteady pressure measurement of approximately + or - 6%, plus 0.1 kPa for a typical application. V.T.

A80-34546 * **Apparatus for trapping and thermal detection of atomic hydrogen in high magnetic fields at low temperatures.** J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio). *Review of Scientific Instruments,* vol. 51, May 1980, p. 602-604. 12 refs.

An apparatus is described in which hydrogen atoms were trapped at temperatures down to 1.1 K in the 11 T field of a large volume superconducting magnet. A high sensitivity thermal detector was used to study trapping and recombination of atoms on the detector surface. The apparatus permits the application of extremely high steady state magnetic fields to study the potential effects of electron spin polarization on the stabilization of hydrogen atoms. (Author)

A80-36127 * # **The measuring and growing of advanced gas turbines.** M. J. Hartmann (NASA, Lewis Research Center, Cleveland, Ohio). In: Measurement methods in rotating components of turbomachinery; Proceedings of the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, La., March 10-13, 1980. (A80-36126 14-35) New York, American Society of Mechanical Engineers, 1980, p. 1-4.

Advances in the gas turbine technology level and the corresponding advances in measurement instruments and technique are reviewed for each of the past decades, starting with the forties. The review provides a picture of the gradual development from the earlier, relatively simple systems, to the present sophisticated machines. A look in the future indicates that continued advances in gas turbine technology will be needed, used, and supported and that substantial changes are underway as to how these advances will be achieved. Some projections of the type of advances and in technology and measurements to be expected in the decade of the eighties are presented. V.P.

A80-36137 * # **Laser-optical blade tip clearance measurement system.** J. P. Barranger (NASA, Lewis Research Center, Cleveland, Ohio) and M. J. Ford (United Technologies Corp., Pratt and Whitney Aircraft Group, West Palm Beach, Fla.). In: Measurement methods in rotating components of turbomachinery; Proceedings of the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, La., March 10-13, 1980. (A80-36126 14-35) New York, American Society of Mechanical Engineers, 1980, p. 127-131.

The need for blade tip clearance instrumentation has been intensified recently by advances in technology of gas turbine engines. A new laser-optical measurement system has been developed to measure single blade tip clearances and average blade tip clearances between a rotor and its gas path seal in rotating component rigs and complete engines. The system is applicable to fan, compressor and turbine blade tip clearance measurements. The engine mounted probe is particularly suitable for operation in the extreme turbine environment. The measurement system consists of an optical subsystem, an electronic subsystem and a computing and graphic terminal. Bench tests and environmental tests were conducted to confirm operation at temperatures, pressures, and vibration levels typically encountered in an operating gas turbine engine. (Author)

A80-36140 * # **Efficient laser anemometer for intra-rotor flow mapping in turbomachinery.** J. A. Powell, A. J. Strazisar, and R. G. Seasholtz (NASA, Lewis Research Center, Cleveland, Ohio). In: Measurement methods in rotating components of turbomachinery; Proceedings of the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, La., March 10-13, 1980. (A80-36126 14-35) New York, American Society of Mechanical Engineers, 1980, p. 157-164. 10 refs.

Innovative features of the anemometer include: (1) a rapid and efficient data acquisition process, (2) a detailed real-time graphic display of the data being accumulated, and (3) input laser beam positioning that maximizes the size of the intra-rotor region being mapped. Results demonstrate the anemometer's capability in flow mapping within a transonic axial-flow compressor rotor. The use of fluorescent seed particles allows flow measurements near the rotor hub and the casing window. (Author)

A80-36141 * # **Laser anemometer measurements in a transonic axial flow compressor rotor.** A. J. Strazisar and J. A. Powell (NASA, Lewis Research Center, Cleveland, Ohio). In: Measurement methods in rotating components of turbomachinery; Proceedings of the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, La., March 10-13, 1980. (A80-36126 14-35) New York, American Society of Mechanical Engineers, 1980, p. 165-176. 11 refs.

A laser anomometer system employing an efficient data acquisition technique has been used to make measurements upstream, within, and downstream of the compressor rotor. A fluorescent dye technique allowed measurements within endwall boundary layers. Adjustable laser beam orientation minimized shadowed regions and enabled radial velocity measurements outside of the blade row. The flow phenomena investigated include flow variations from passage to passage, the rotor shock system, three-dimensional flows in the blade wake, and the development of the outer endwall boundary layer. Laser anemometer measurements are compared to a numerical solution of the streamfunction equations and to measurements made with conventional instrumentation. (Author)

A80-36145 * # **Fluid and structural measurements to advance gas turbine technology.** M. J. Hartmann (NASA, Lewis Research Center, Cleveland, Ohio). In: Measurement methods in rotating components of turbomachinery; Proceedings of the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, La., March 10-13, 1980. (A80-36126 14-35) New York, American Society of Mechanical Engineers, 1980, p. 209-213.

In the present paper, the current status of fluid and structural measurements is reviewed, and some potential improvements in gas turbine machinery, directly associated with the new measuring capability are discussed. Some considerations concerning the impact of the new capability on the methods and approaches that will be used in the further development of advanced technology, in general, and to aeropropulsion gas turbine machinery, in particular, are presented. V.P.

A80-36147 * # **Flutter spectral measurements using stationary pressure transducers.** A. P. Kurkov (NASA, Lewis Research Center, Cleveland, Ohio). In: Measurement methods in rotating components of turbomachinery; Proceedings of the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, La., March 10-13, 1980. (A80-36126 14-35) New York, American Society of Mechanical Engineers, 1980, p. 225-233. 6 refs.

The paper deals with an analysis procedure, based on engine-order sampling, which eliminates effectively the engine harmonics from the overall flutter spectra obtained with a case-mounted static pressure transducer. Qualitative spectral analyses of pressure data, performed on the basis of blade order sampling, are examined. The interference of blade motion with the pressure signal in the steep gradient portion of the blade passage is demonstrated, using optimal displacement spectra. Two methods which remove the contribution of blade motion from the blade-pressure-difference spectra are described. V.P.

A80-36151 * # **Digital system for dynamic turbine engine blade displacement measurements.** L. J. Kiraly (NASA, Lewis Research Center, Cleveland, Ohio). In: Measurement methods in rotating components of turbomachinery; Proceedings of the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, La., March 10-13, 1980. (A80-36126 14-35) New York, American Society of Mechanical Engineers, 1980, p. 255-262.

The paper presents a technique for measuring blade tip displacements which employs optical probes and an array of microcomputers. A system directly digitizing a minimum of a 2048-point time-deflection history for each of the three measurement locations on each blade is described. V.T.

A80-36155 * # **Impact of new instrumentation on advanced turbine research.** R. W. Graham (NASA, Lewis Research Center, Cleveland, Ohio). In: Measurement methods in rotating components of turbomachinery; Proceedings of the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, La., March 10-13, 1980. (A80-36126 14-35) New York, American Society of Mechanical Engineers, 1980, p. 289-302. 23 refs.

The progression of experimental programs is discussed from the simplest two-dimensional stationary geometry to the highly complex three-dimensional flow in a rotating blade row. Experimental methods and instrumentation techniques are described. Emphasis is placed on rotating blade row measurements. V.T.

A80-36157 * # **Temperature and pressure measurement techniques for an advanced turbine test facility.** F. G. Pollack and R. P. Cochran (NASA, Lewis Research Center, Cleveland, Ohio). In: Measurement methods in rotating components of turbomachinery; Proceedings of the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, La., March 10-13, 1980. (A80-36126 14-35) New York, American Society of Mechanical Engineers, 1980, p. 319-326. 13 refs.

A high pressure, high-temperature turbine test facility is being constructed at the NASA Lewis Research Center for use in turbine cooling research. Several recently developed temperature and pressure measuring techniques will be used in this facility. This paper describes these measurement techniques, their status, previous applications and some results. Noncontact surface temperature measurements will be made by optical methods. Radiation pyrometry principles combined with photoelectric scanning will be used for rotating components and infrared photography for stationary components. Contact (direct) temperature and pressure measurements on rotating components will be handled with an 80-channel rotary data package which mounts on and rotates with the turbine shaft at speeds up to 17,500 rpm. The data channels are time-division multiplexed and converted to digital words in the data package. A rotary transformer couples power and digital data to and from the shaft. (Author)

A80-42291 * # **Fatigue strength testing employed for evaluation and acceptance of jet-engine instrumentation probes.** E. C. Armentrout (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper.* 23 p. 15 refs. Members, $1.50; nonmembers, $3.00.

This report outlines the fatigue type testing performed on instrumentation rakes and probes intended for use in the air flow passages of jet-engines during full-scale engine tests at Lewis Research Center. Included is a discussion of each type of test performed, the results that may be derived and means of inspection. A design and testing sequence outlines the procedures and considerations involved in the generation of suitable instrument probes. (Author)

A80-44233 * # **Simulation of transducer-couplant effects on broadband ultrasonic signals.** A. Vary (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Nondestructive Testing, Spring Meeting, Philadelphia, Pa., Mar. 24-27, 1980, Paper.* 34 p. 9 refs.

The increasing use of broadband, pulse-echo ultrasonics in nondestructive evaluation of flaws and material properties has generated a need for improved understanding of the way signals are modified by coupled and bonded thin-layer interfaces associated with transducers. This understanding is most important when using frequency spectrum analyses for characterizing material properties. In this type of application, signals emanating from material specimens can be strongly influenced by couplant and bond-layers in the acoustic path. Computer synthesized waveforms were used to simulate a range of interface conditions encountered in ultrasonic transducer systems operating in the 20- to 80-MHz regime. The adverse effects of thin-layer multiple reflections associated with various acoustic impedance conditions are demonstrated. The information presented is relevant to ultrasonic transducer design, specimen preparation, and couplant selection. (Author)

N80-14375*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFICIENT LASER ANEMOMETER FOR INTRA-ROTOR FLOW MAPPING IN TURBOMACHINERY
J. Anthony Powell, Anthony J. Strazisar, and Richard G. Seasholtz 1979 11 p refs Proposed for presentation at the ASME 25th Ann. Intern. Gas Turbine Conf., and the 22nd Ann. Fluids Eng. Conf., New Orleans, 9-13 Mar. 1980
(NASA-TM-79320; E-276) Avail: NTIS HC A02/MF A01 CSCL 14B

A fringe type laser anemometer is described. Features of the anemometer include: a rapid and efficient data acquisition process; a detailed real time graphic display of the data being accumulated; and input laser beam positioning that maximizes the size of the intrarotor region being mapped. Results are presented that demonstrate the anemometer's capability in flow mapping within a transonic axial flow compressor rotor. A velocity profile, derived from 30,000 measurements along 1000 sequential circumferential positions covering 20 blade passages, was obtained in 30 seconds. The use of fluorescent seed particles allowed flow measurements near the rotor hub and the casing window. R.C.T.

N80-17425*# Pratt and Whitney Aircraft, East Hartford, Conn.
THIN FILM TEMPERATURE SENSOR
H. P. Grant and J. S. Przybyszewski 15 Feb. 1980 61 p refs
(Contract NAS3-20768)
(NASA-CR-159782; PWA-5526-31) Avail: NTIS HC A04/MF A01 CSCL 14B

Thin film surface temperature sensors were developed. The sensors were made of platinum-platinum/10 percent rhodium thermocouples with associated thin film-to-lead wire connections and sputtered on aluminum oxide coated simulated turbine blades for testing. Tests included exposure to vibration, low velocity hydrocarbon hot gas flow to 1250 K, and furnace calibrations. Thermal electromotive force was typically two percent below standard type S thermocouples. Mean time to failure was 42 hours at a hot gas flow temperature of 1250 K and an average of 15 cycles to room temperature. Failures were mainly due to separation of the platinum thin film from the aluminum oxide surface. Several techniques to improve the adhesion of the platinum are discussed. R.E.S.

N80-31777*# United Technologies Research Center, East Hartford, Conn.
DESIGN, FABRICATION AND TESTING OF AN OPTICAL TEMPERATURE SENSOR
W. W. Morey, W. H. Glenn, R. O. Decker, and W. C. McClurg Jul. 1980 54 p refs
(Contract NAS3-21841)
(NASA-CR-165125; R80-924624-11) Avail: NTIS HC A04/MF A01 CSCL 14B

The laboratory breadboard optical temperature sensor based on the temperature dependent absorptive characteristics of a rare earth (europium) doped optical fiber. The principles of operation, materials characterization, fiber and optical component design, design and fabrication of an electrooptic interface unit, signal processing, and initial test results are discussed. Initial tests indicated that, after a brief warmup period, the output of the sensor was stable to approximately 1 C at room temperature or approximately + or - 0.3 percent of point (K). This exceeds the goal of 1 percent of point. Recommendations are presented for further performance improvement. L.F.M.

36 LASERS AND MASERS

Includes parametric amplifiers.

N80-14386*# Rasor Associates, Inc., Sunnyvale, Calif.
A CESIUM TELEC EXPERIMENT AT LEWIS RESEARCH CENTER Final Report
E. J. Britt Sep. 1979 59 p refs
(Contract NAS3-21149)
(NASA-CR-159729; NSR-8-1) Avail: NTIS HC A04/MF A01 CSCL 20E

The thermoelectronic laser energy converter (TELEC), was studied as a method of converting a 10.6 mm CO2 laser beam into electric power. The calculated characteristics of a TELEC seem to be well matched to the requirements of a spacecraft laser energy conversion system. The TELEC is a high power density plasma device which absorbs an intense laser beam by inverse bremsstrahlung with the plasma electrons. In the TELEC process, electromagnetic radiation is absorbed directly in the plasma electrons producing a high electron temperature. The energetic electrons diffuse out of the plasma striking two electrodes which are in contact with the plasma at the boundaries. These two electrodes have different areas: the larger one is designated as the collector, the smaller one is designated as the emitter. The smaller electrode functions as an electron emitter to provide continuity of the current. Waste heat is rejected from the collector electrode. An experiment was carried out with a high power laser using a cesium vapor TELEC cell with 30 cm active length. Laser supported plasma was produced in the TELEC device during a number of laser runs over a period of several days. Electric power from the TELEC was observed with currents in the range of several amperes and output potentials of less than 1 volt. The magnitudes of these electric outputs were smaller

37 MECHANICAL ENGINEERING

Includes auxiliary systems (non-power); machine elements and processes; and mechanical equipment.

N80-12414*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MODIFIED FACE SEAL FOR POSITIVE FILM STIFFNESS Patent Application
Izhak Etsion (Technion-Israel Inst. of Technol., Haifa) and Abraham Lipshitz, inventors (to NASA) (Technion-Israel Inst. of Technol., Haifa) Filed 7 Nov. 1979 7 p Sponsored by NASA
(NASA-Case-LEW-12989-1; US-Patent-Appl-SN-092145) Avail: NTIS HC A02/MF A01 CSCL 11A

An invention to improve the film stiffness of a face seal without increasing the sealing and dam area is described. The improved sealing apparatus has a primary seal ring in the form of a nose piece. A spring forces a sealing surface on the seal ring into sealing contact with a seat to form a face seal. A circumferential clearance seal is formed in series with this face by a lip on the nose piece. The width of the surface of the lip is substantially the same as the width of the sealing surface on the face seal. Also, the clearance between the surface on the lip and the shaft is substantially the same as the spacing between the face sealing surfaces on the face seal when the shaft is rotating. The circumferential clearance seal restricts the flow of fluid from a main cavity to an intermediate cavity with a resulting pressure drop. The hydrostatic opening is strongly dependent on the face seal clearance, and the desired axial stiffness is achieved. NASA

N80-13473*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INVESTIGATION INTO THE EFFECT OF PLASMA PRE-TREATMENT ON THE ADHESION OF PARYLENE TO VARIOUS SUBSTRATES
T. Riley, T. Cobo Mahuson, and K. Seibert 1979 20 p refs
Presented at the Seminar of Cleaning, Finishing and Coating Processes, Los Angeles, 5-6 Feb. 1979; sponsored by the Soc. for the Advan. of Mater. and Process Eng.
(NASA-TM-79224; E-119) Avail: NTIS HC A02/MF A01 CSCL 11A

A procedure is described for using argon and oxygen plasmas to promote adhesion of parylene coatings upon many difficult-to-bond substrates. Substrates investigated were gold, nickel, kovar, teflon (FEP), kapton, silicon, tantalum, titanium, and tungsten. Without plasma treatment, 180 deg peel tests yield a few g/cm (oz/in) strengths. With dc plasma treatment in the deposition chamber, followed by coating, peel strengths are increased by one to two orders of magnitude. A.R.H.

N80-14403*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SELF-ACTING LIFT-PAD GEOMETRY FOR CIRCUMFERENTIAL SEALS: A NONCONTACTING CONCEPT
Gordon P. Allen Jan. 1980 11 p refs
(NASA-TP-1583; E-154) Avail: NTIS HC A02/MF A01 CSCL 11A

A segmented circumferential seal with lift pads for hydrodynamic action was analyzed over ranges of speed and sealed pressure. Performance predictions, which predicted noncontact operation for speeds as high as 600 revolutions per second at sealed pressures to 86 N/sq cm, are discussed. Performance tests were performed on the seals and compared with the performance predictions. A.W.H.

N80-15410*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARISON OF PREDICTED AND EXPERIMENTAL PERFORMANCE OF LARGE-BORE ROLLER BEARING OPERATING TO 3.0 MILLION DN
Harold H. Coe and Frederick T. Huller Jan. 1980 20 p refs
(NASA-TP-1599; E-063) Avail: NTIS HC A02/MF A01 CSCL 13I

Bearing inner and outer race temperatures and the amount of heat transferred to the lubricant were calculated by using the computer program CYBEAN. The results obtained were compared with previously reported experimental data for a 118 mm bore roller bearing that operated at shaft speeds to 25,500 rpm, radial loads to 8,900 N (2000 lb), and total lubricant flow rates to 0.0102 cu m/min (2.7 gal/min). The calculated results compared well with the experimental data. Author

N80-16340*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TRIBOLOGICAL PROPERTIES OF SILICON CARBIDE IN METAL REMOVAL PROCESS
Kazuhisa Miyoshi and Donald H. Buckley 1980 18 p refs
To be presented at Intern. Symp. on Metal Working Lubrication, San Francisco, 18-19 Aug. 1980; sponsored by ASME
(NASA-TM-79238) Avail: NTIS HC A02/MF A01 CSCL 13H

Material properties are considered as they relate to adhesion, friction, and wear of single crystal silicon carbide in contact with metals and alloys that are likely to be involved in a metal removal process such as grinding. Metal removal from adhesion between sliding surfaces in contact and metal removal as a result of the silicon carbide sliding against a metal, indenting into it, and plowing a series of grooves or furrows are discussed. Fracture and deformation characteristics of the silicon carbide surface are also covered. The adhesion, friction, and metal transfer to silicon carbide is related to the relative chemical activity of the metals. The more active the metal, the higher the adhesion and friction, and the greater the metal transfer to silicon carbipe. Atomic size and content of alloying elements play a dominant role in controlling adhesion, friction, and abrasive wear properties of alloys. The friction and abrasive wear (metal removal) decrease linearly as the shear strength of the bulk metal increases. They decrease as the solute to solvent atomic radius ratio increases or decreases linearly from unity, and with an increase of solute content. The surface fracture of silicon carbide is due to cleavages of 0001, 10(-1)0, and/or 11(-2)0 planes. J.M.S.

N80-16341*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF WEAR-DEBRIS FROM FULL-SCALE BEARING FATIGUE TESTS USING THE FERROGRAPH
William R. Jones and Stuart H. Loewenthal 1980 22 p refs
Prepared for presentation at the Ann. Meeting of the Am. Soc. of Lubrication Engr., Anaheim, Calif., 5-8 May 1980
(NASA-TM-81403; E-9827) Avail: NTIS HC A02/MF A01 CSCL 13H

The ferrograph was used to determine the types and quantities of wear particles generated during full-scale bearing fatigue tests. Deep-groove ball bearings made from AISI 52100 steel were used. A MIL-L-23699 tetraester lubricant was used in a recirculating lubrication system containing a 49 mm absolute filter. Test conditions included a maximum Hertz stress of 2.4 GPa, a shaft speed of 15,000 rpm, and a lubricant supply temperature of 74 C (165 F). Four fatigue failures were detected by accelerometers in this test set. In general, the ferrograph was more sensitive (up to 23 hr) in detecting spall initiation than either accelerometers or the normal spectrographic oil analysis. Four particle types were observed: normal rubbing wear particles, spheres, nonferrous particles, and severe wear (spall) fragments. Author

N80-16342*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF COMPUTER-OPTIMIZED TAPERED-ROLLER BEARINGS TO 2.4 MILLION DN
R. J. Parker, S. I. Pinel (Industrial Tectonics, Inc., Compton, Calif.), and H. R. Signer (Industrial Tectonics, Inc., Compton, Calif.) 1980 29 p refs Proposed for presentation at the Intern. Lubrication Conf., San Francisco, 18-21 Aug. 1980; sponsored by ASME and the Am. Soc. of Lubrication Engr.

(NASA-TM-81414; E-332) Avail: NTIS HC A03/MF A01 CSCL 13I

The performance of 120.65 mm bore high speed design tapered roller bearings was investigated at shaft speeds to 20,000 rpm under combined thrust and radial load. The test bearing design was computer optimized for high speed operation. Temperature distribution and bearing heat generation were determined as a function of shaft speed, radial and thrust loads, lubricant flow rates, and lubricant inlet temperature. The roller bearing operated successfully at shaft speeds up to 20,000 rpm under heavy thrust and radial loads. Cup cooling was effective in decreasing the high cup temperatures to levels equal to the cone temperature. K.L.

N80-17466*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPUR-GEAR-SYSTEM EFFICIENCY AT PART AND FULL LOAD
Neil E. Anderson and Stuart H. Loewenthal Feb. 1980 42 p refs Prepared in cooperation with Army Aviation Res. and Develop. Command, Cleveland
(NASA-TP-1622; AVRADCOM-TR-79-46; E-061) Avail: NTIS HC A03/MF A01 CSCL 13I

A simple method for predicting the part- and full-load power loss of a steel spur gearset of arbitrary geometry supported by ball bearings is described. The analysis algebraically accounts for losses due to gear sliding, rolling traction, and windage in addition to support-ball-bearing losses. The analysis compares favorably with test data. A theoretical comparison of the component losses indicates that losses due to gear rolling traction, windage, and support bearings are significant and should be included along with gear sliding loss in a calculation of gear-system power loss. M.G.

N80-17467*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE SENSITIVITY ANALYSIS OF DEPARTMENT OF ENERGY-CHRYSLER UPGRADED AUTOMOTIVE GAS TURBINE ENGINE, S/N 5-4 Final Report
Roy L. Johnsen Dec. 1979 37 p refs
(Contract EC-77-A-31-1040)
(NASA-TM-79242; DOE/NASA/1040-79/9; E-147) Avail: NTIS HC A03/MF A01 CSCL 21A

The performance sensitivity of a two-shaft automotive gas turbine engine to changes in component performance and cycle operating parameters was examined. Sensitivities were determined for changes in turbomachinery efficiency, compressor inlet temperature, power turbine discharge temperature, regenerator effectiveness, regenerator pressure drop, and several gas flow and heat leaks. Compressor efficiency was found to have the greatest effect on system performance. K.L.

N80-17469*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SIMPLIFIED FATIGUE LIFE ANALYSIS FOR TRACTION DRIVE CONTACTS
Douglas A. Rohn, Stuart H. Loewenthal, and John J. Coy 1980 30 p refs Proposed for presentation at 3d Intern. Power Transmission and Gearing Conf., San Francisco, 18-22 Aug. 1980; sponsored by ASME Prepared in cooperation with Army Aviation Res. and Develop. Command, Cleveland
(NASA-TM-79199; AVRADCOM-TR-80-C-4; E-355) Avail: NTIS HC A03/MF A01 CSCL 13I

A simplified fatigue life analysis for traction drive contacts of arbitrary geometry is presented. The analysis is based on the Lundberg-Palmgren theory used for rolling-element bearings. The effects of torque, element size, speed, contact ellipse ratio, and the influence of traction coefficient are shown. The analysis shows that within the limits of the available traction coefficient, traction contacts exhibit longest life at high speeds. Multiple, load-sharing roller arrangements have an advantageous effect on system life, torque ·ity, power-to-weight ratio and size. Author

N80-18400*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GAS PATH SEAL Patent Application
Robert C. Bill and Robert D. Johnson, inventors (to NASA) Filed 20 Nov. 1979 8 p
(NASA-Case-NPO-12131-3; US-Patent-Appl-SN-096255) Avail: NTIS HC A02/MF A01 CSCL 20A

A gas path seal suitable for use with a turbine engine or compressor is described. A shroud wearable or abradable by the abrasion of the rotor blades of the turbine or compressor shrouds the rotor bades. A compliant backing surrounds the shroud. The backing is a yieldingly deformable porous material covered with a thin ductile layer. A mounting fixture surrounds the backing. NASA

N80-18401*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CIRCUMFERENTIAL SHAFT SEAL Patent Application
L. P. Ludwig, inventor (to NASA) Filed 7 Dec. 1979 8 p
(NASA-Case-LEW-12119-2; US-Patent-Appl-SN-102004) Avail: NTIS HC A02/MF A01 CSCL 20A

A circumferential shaft seal in which the seal elements are capable of adequate response to shaft motion is described. The seal is comprised of two sealing rings held to a rotating shaft by means of a surrounding elastomeric band. The rings are segmented and have an inner diameter dimensioned so that the segments can slidably and sealably engage the shaft. Alternative embodiments of the seal concept are described and suggestions for component materials are given. M.G.

N80-18403*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL AND EXPERIMENTAL SPUR GEAR TOOTH TEMPERATURE AS AFFECTED BY OPERATING VARIABLES
Dennis P. Townsend and Lee S. Akin (Western Gear Corp., Industry, Calif.) 1980 29 p refs Presented at 3d Intern. Power Transmission and Gearing Conf., San Francisco, Calif., 18-22 Aug. 1980; sponsored by Am. Soc. of Mech. Engr.
(NASA-TM-81419; E-342) Avail: NTIS HC A03/MF A01 CSCL 13I

A gear tooth temperature analysis was performed using a finite element method combined with a calculated heat input, calculated oil jet impingement depth, and estimated heat transfer coefficients. Experimental measurements of gear tooth average surface temperatures and instantaneous surface temperatures were made with a fast response infrared radiometric microscope. Increased oil jet pressure had a significant effect on both average and peak surface temperatures at both high load and speeds. Increasing the speed at constant load and increasing the load at constant speed causes a significant rise in average and peak surface temperatures of gear teeth. The oil jet pressure required for adequate cooling at high speed and load conditions must be high enough to get full depth penetration of the teeth. Calculated and experimental results were in good agreement with high oil jet penetration but showed poor agreement with low oil jet penetration depth. Author

N80-18404*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EVALUATION OF A HIGH PERFORMANCE FIXED-RATIO TRACTION DRIVE
Stuart H. Loewenthal, Neil E. Anderson, and Douglas A. Rohn 1980 32 p refs Proposed for presentation at 3d Intern. Power Transmission and Gearing Conf., San Francisco, Calif., 18-22 Aug. 1980; sponsored by Am. Soc. of Mech. Engr.
(NASA-TM-81425; E-349) Avail: NTIS HC A03/MF A01 CSCL 13I

The results of a test program to evaluate a compact, high performance, fixed ratio traction drive are presented. This transmission, the Nasvytis Multiroller Traction Drive, is a fixed ratio, single stage planetary with two rows of stepped planet rollers. Two versions of the drive were parametrically tested back-to-back at speeds to 73,000 rpm and power levels to 180 kW (240 hp). Parametric tests were also conducted with the Nasvytis drive retrofitted to an automotive gas turbine engine. The drives exhibited good performance, with a nominal peak efficiency of 94 to 96 percent and a maximum speed loss due to creep of approximately 3.5 percent. Author

N80-18405*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ENDURANCE AND FAILURE CHARACTERISTICS OF MODIFIED VASCO X-2, CBS 600 AND AISI 9310 SPUR GEARS
Dennis P. Townsend and E. V. Zaretsky 1980 28 p refs Proposed for presentation at 3d Intern. Power Transmission and Gearing Conf., San Francisco, Calif., 18-22 Aug. 1980; sponsored by Am. Soc. of Mech. Engr.
(NASA-TM-81421; E-344) Avail: NTIS HC A03/MF A01 CSCL 13I

Gear endurance tests and rolling-element fatigue tests were conducted to compare the performance of spur gears made from AISI 9310, CBS 600 and modified Vasco X-2 and to compare the pitting fatigue lives of these three materials. Gears manufactured from CBS 600 exhibited lives longer than those manufactured from AISI 9310. However, rolling-element fatigue tests resulted in statisitcally equivalent lives. Modified Vasco X-2 exhibited statistically equivalent lives to AISI 9310. CBS 600 and modified Vasco X-2 gears exhibited the potential of tooth fracture occurring at a tooth surface fatigue pit. Case carburization of all gear surfaces for the modified Vasco X-2 gears results in fracture at the tips of the gears. Author

N80-18406*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF GEOMETRY AND OPERATING CONDITIONS ON SPUR GEAR SYSTEM POWER LOSS
Neil E. Anderson and Stuart H. Loewenthal 1980 31 p refs Proposed for presentation at 3d Intern. Power Transmission and Gearing Conf., San Francisco, Calif., 18-22 Aug. 1980; sponsored by Am. Soc. of Mech. Engr.
(NASA-TM-81426; E-350; AVRADCOM-TR-80-C-2) Avail: NTIS HC A03/MF A01 CSCL 20I

The results of an analysis of the effects of spur gear size, pitch, width, and ratio on total mesh power loss for a wide range of speeds, torques, and oil viscosities are presented. The analysis uses simple algebraic expressions to determine gear sliding, rolling, and windage losses and also incorporates an approximate ball bearing power loss expression. The analysis shows good agreement with published data. Large diameter and fine pitched gears had higher peak efficiencies but low part load efficiency. Gear efficiencies were generally greater than 98 percent except at very low torque levels. Tare (no-load) losses are generally a significant percentage of the full load loss except at low speeds. Author

N80-18407*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONSTRAINED FATIGUE LIFE OPTIMIZATION OF A NASVYTIS MULTIROLLER TRACTION DRIVE
John J. Coy, Douglas A. Rohn, and Stuart H. Loewenthal 1980 20 p refs Proposed for presentation at 3d Intern. Power Transmission and Gearing Conf., San Francisco, Calif., 18-22 Aug. 1980; sponsored by Am. Soc. of Mech. Engr.
(NASA-TM-81447; AVRADCOM-TR-80-C-6; E-214) Avail: NTIS HC A02/MF A01 CSCL 13I

A contact fatigue life analysis method for multiroller traction drives is presented. The method is based on the Lundberg-Palmgren analysis method for rolling element bearing life prediction, and also uses life adjustment factors for materials, processing, lubrication, and effect of traction. The analysis method is applied in an optimization study to the multiroller traction drive, consisting of a single-stage planetary configuration with two rows of stepped planet rollers of five rollers per row. The drive was approximately 25 centimeters in diameter by 11 centimeters long, having a nominal ratio of 15:1. The theoretically predicted drive life was 2510 hours at a nominal continuous power and speed of 74.6 kW (100 hp) and 7500 rpm. Author

N80-18408*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS AND DESIGN OF A UNIFORM-CLEARANCE, PUMPING-RING ROD SEAL FOR THE STIRLING ENGINE
I. Etsion Mar. 1980 30 p refs
(NASA-TM-81463; E-080) Avail: NTIS HC A03/MF A01 CSCL 11A

A uniform clearance pumping ring, as opposed to the conventional taper clearance one, is described. The uniform clearance concept eliminates complex elastohydrodynamic problems and enables a simple analytical treatment to be made. An analytical expression is derived for the pumping rate showing the effect of various design parameters on the pumping ring's performance. An optimum clearance is found by which the pumping rate is maximized and a numerical example is presented to demonstrate the potential of the uniform clearance design. Author

N80-18409*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOME LIMITATIONS IN APPLYING CLASSICAL EHD FILM-THICKNESS FORMULAE TO A HIGH-SPEED BEARING
John J. Coy and Erwin V. Zaretsky 1980 32 p refs Proposed for presentation at Intern. Lubrication Conf., San Francisco, 18-21 Aug. 1980; sponsored by Am. Soc. of Mech. Engr. and Am. Soc. of Lubrication Engr.
(NASA-TM-81431; AVRADCOM-TR-80-C-3; E-198) Avail: NTIS HC A03/MF A01 CSCL 13I

Elastohydrodynamic film thickness was measured for a 20 mm ball bearing using the capacitance technique. The bearing was thrust loaded to 90, 448, and 778 N. The corresponding maximum stresses on the inner race were 1.28, 2.09, and 2.45 GPa. Test speeds ranged from 400 to 14,000 rpm. Film thickness measurements were taken with four different lubricants: (1) synthetic paraffinic; (2) synthetic paraffinic with additives; (3) neopentylpolyol (tetra) ester; and (4) synthetic cycloaliphatic hydrocarbon traction fluid. The test bearing was mist lubricated. Test temperatures were 300, 338, and 393 K. The measured results were compared to theoretical predictions and are presented. A.W.H.

N80-19495*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DAMPING IN TAPERED ANNULAR SEALS FOR AN INCOMPRESSIBLE FLUID
David P. Fleming Apr. 1980 22 p refs
(NASA-TP-1646; E-124) Avail: NTIS HC A02/MF A01 CSCL 11A

Damping in annular seals is calculated for an incompressible fluid. Results show that damping in tapered seals optimized for stiffness is considerably less than that in straight seals for the same minimum clearance. Damping in rotating seals can promote fractional frequency whirl. Neglecting fluid acceleration makes solution much easier, but leads to errors in calculated damping of up to 16 percent. K.L.

N80-19496*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CALCULATED AND EXPERIMENTAL DATA FOR A 118-mm BORE ROLLER BEARING TO 3 MILLION DN
Harold H. Coe and Frederick T. Schuller 1980 37 p refs Proposed for presentation at Intern. Lubrication Conf., San Francisco, 18-21 Aug. 1980; sponsored by ASME and the Am. Soc. of Lubrication Engr.
(NASA-TM-81427; E-063) Avail: NTIS HC A03/MF A01 CSCL 13I

The operating characteristics for 118 mm bore cylindrical roller bearing are examined using the computer program CYBEAN. The predicted results of inner and outer-race temperatures and heat transferred to the lubricant generally compared well with experimental data for shaft speeds to 3 million DN (25,000 rpm), radial loads to 8900 N (2000 lb), and total lubricant flow rates to 0.0102 cu m/min (2.7 gal/min). M.G.

N80-19497*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FERROGRAPHIC AND SPECTROGRAPHIC ANALYSIS OF OIL SAMPLED BEFORE AND AFTER FAILURE OF A JET ENGINE

William R. Jones, Jr. Feb. 1980 20 p refs
(NASA-TM-81430; E-353) Avail: NTIS HC A02/MF A01 CSCL 21E

An experimental gas turbine engine was destroyed as a result of the combustion of its titanium components. Several engine oil samples (before and after the failure) were analyzed with a Ferrograph as well as plasma, atomic absorption, and emission spectrometers. The analyses indicated that a lubrication system failure was not a causative factor in the engine failure. Neither an abnormal wear mechanism, nor a high level of wear debris was detected in the oil sample from the engine just prior to the test in which the failure occurred. However, low concentrations of titanium were evident in this sample and samples taken earlier. After the failure, higher titanium concentrations were detected in oil samples taken from different engine locations. Ferrographic analysis indicated that most of the titanium was contained in spherical metallic debris after the failure. K.L.

N80-19498*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IDEAL SPIRAL BEVEL GEARS: A NEW APPROACH TO SURFACE GEOMETRY

R. L. Huston (Cincinnati Univ., Ohio) and J. J. Coy 1980 22 p refs Proposed for presentation at 3d Intern. Power Transmission and Gearing Conf., San Francisco, 18-22 Aug. 1980; sponsored by ASME
(NASA-TM-81446; E-366; AVRADCOM-TR-80-C-5) Avail: NTIS HC A02/MF A01 CSCL 13I

The fundamental geometrical characteristics of spiral bevel gear tooth surfaces are discussed. The parametric representation of an ideal spiral bevel tooth is developed based on the elements of involute geometry, differential geometry, and fundamental gearing kinematics. A foundation is provided for the study of nonideal gears and the effects of deviations from ideal geometry on the contact stresses, lubrication, wear, fatigue life, and gearing kinematics. M.G.

N80-20591*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LUBRICATION OF ROLLING-ELEMENT BEARINGS

Richard J. Parker [1980] 26 p refs Proposed for presentation at Intern. Lubrication Conf., San Francisco, 18-21 Aug. 1980; sponsored by ASME and the Am. Soc. of Lubrication Engr.
(NASA-TM-81449; E-370) Avail: NTIS HC A03/MF A01 CSCL 13I

The lubrication of rolling element bearings is surveyed. Emphasis is on the critical design aspects related to speed, temperature, and ambient pressure environment. Types of lubrication including grease, jets, mist, wick, and through the race are discussed. The historical development, present state of technology, and the future problems of rolling element bearing lubrication are discussed. A.W.H.

N80-21753*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPERATING CHARACTERISTICS OF HIGH-SPEED, JET-LUBRICATED 35-MILLIMETER-BORE BALL BEARING WITH A SINGLE-OUTER-LAND-GUIDED CAGE

Fredrick T. Schuller, Stanley I. Pinel (Industrial Tectonics, Inc.), and Hans R. Signer (Industrial Tectonics, Inc.) Washington Apr. 1980 16 p refs
(NASA-TP-1657; E-220) Avail: NTIS HC A02/MF A01 CSCL 13I

Parametric tests of a 35 mm bore, angular contact ball bearing with a single outer land guided cage were conducted on a high temperature, high speed bearing tester. Provisions were made for jet lubrication of the bearing and for outer ring cooling. Test conditions included two different thrust loads and a combined thrust and radial load. Nominal shaft speeds were 28,000 to 72,000 rpm, with an oil-in temperature of 394 K (250 F). The bearing was successfully operated to 2.5 million DN at a maximum thrust load of 1334 N (300 lb) and at a combined 667 N (150-lb) thrust and 222 N (50-lb) radial load. Bearing temperatures increased with shaft speed and decreased with increasing lubricant flow rate. Inner-ring temperature was generally lower than outer ring temperature. Lower operating temperatures resulted from cooling the outer ring. Bearing power loss increased as the lubricant flow rate, speed, or load was increased. The increase in percent cage slip with increasing lubricant flow rate was minimal for all speed and load conditions tested. Percent cage slip decreased significantly when the thrust load was doubled, but it increased appreciably with speed. Author

N80-21754*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PARAMETRIC TESTS OF A TRACTION DRIVE RETRO-FITTED TO AN AUTOMOTIVE GAS TURBINE

Douglas A. Rohn, Stuart H. Lowenthal, and Neil E. Anderson 1980 21 p refs Presented at the 5th Intern. Automotive Propulsion Systems Symp., Dearborn, Mich., 14-18 Apr. 1980 Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, Ohio
(Contract EF-77-A-31-1011)
(NASA-TM-81457; AVRADCOM-TR-80-8; DOE/NASA/1011-80/4) Avail: NTIS HC A02/MF A01 CSCL 13I

The results of a test program to retrofit a high performance fixed ratio Nasvytis Multiroller Traction Drive in place of a helical gear set to a gas turbine engine are presented. Parametric tests up to a maximum engine power turbine speed of 45,500 rpm and to a power level of 11 kW were conducted. Comparisons were made to similar drives that were parametrically tested on a back-to-back test stand. The drive showed good compatibility with the gas turbine engine. Specific fuel consumption of the engine with the traction drive speed reducer installed was comparable to the original helical gearset equipped engine. Author

N80-22701*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DYNAMIC RESPONSE TO ROTATING-SEAT RUNOUT IN NON-CONTACTING FACE SEALS

I. Etsion Apr. 1980 25 p refs
(NASA-TM-81490; E-392) Avail: NTIS HC A02/MF A01 CSCL 11A

The dynamic response of a flexibly mounted ring to runout of the rotating seat in mechanical face seals is analyzed assuming small perturbations. It is found that tracking ability of the stator depends only on its dynamic characteristics and operating conditions and is not affected by the amount of runout. Three different modes of dynamic response are shown and the condition for parallel tracking is presented. Author

N80-24619*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FULLY PLASMA-SPRAYED COMPLIANT BACKED CERAMIC TURBINE SEAL Patent Application

R. C. Bill, inventor (to NASA) Filed 30 Apr. 1980 7 p
(NASA-Case-LEW-13268-1; US-Patent-Appl-SN-145209) Avail: NTIS HC A02/MF A01 CSCL 11A

To maintain the minimum operating clearances between the blade tips and the lining of a high pressure turbine, a low temperature easily decomposable material, such as a polymer, in powder form is blended with a high temperature oxidation resistant metal powder. The two materials are simultaneously deposited on a substrate formed by the turbine casing. Alternately, the polymer powder may be added to the metal powder during plasma spraying. A ceramic layer is then deposited directly onto the metal-polymer composite. The polymer additive mixed with the metal is then completely volatilized to provide a porous layer between the ceramic layer and the substrate. Thermal stresses are reduced by virtue of the resulting porous structure which affords a cushion effect. By using plasma spraying for depositing both the powders of the metal and polymer material, as well as the ceramic powder, no brazing is required. NASA

N80-26658* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
COMPOSITE SEAL FOR TURBOMACHINERY Patent
Robert C. Bill and Lawrence P. Ludwig, inventors (to NASA) Issued 10 Jun 1980 4 p Filed 4 Aug. 1978 Supersedes N78-31103 (16 - 22, p 2897) Division of US Patent Appl. SN-801290, filed 27 May 1977, US Patent-4,135,851
(NASA-CASE-LEW-12131-2; US-Patent-4,207,024; US-Patent-Appl-SN-931090; US-Patent-Class-415-174; US-Patent-Class-415-196; US-Patent-Appl-SN-801290; US-Patent-4,135,851) Avail: US Patent and Trademark Office CSCL 11A

A gas path seal suitable for use with a turbine engine or compressor is provided. A shroud wearable or abradable by the abrasion of the rotor blades of the turbine or compressor shrouds the rotor blades. A compliant backing surrounds the shroud. The backing is a compliant material covered with a thin ductile layer. A mounting fixture surrounds the backing.
Official Gazette of the U.S. Patent and Trademark Office

N80-26659*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DIESEL ENGINE CATALYTIC COMBUSTOR SYSTEM Patent Application
Lloyd W. Ream, inventor (to NASA) Filed 6 Jun. 1980 10 p
(NASA-Case-Lew-12995-1; US-Patent-Appl-SN-157150) Avail: NTIS HC A02/MF A01 CSCL 21A

A low compression turbocharged diesel engine is described in which the turbocharger can be operated independently of the engine to power auxiliary equipment. Fuel and air are burned in a catalytic combustor to drive the turbine wheel of the turbine section which is initially caused to rotate by the starter motor. By opening a flapper valve, compressed air from the blower section is directed to the catalytic combustor when it is heated and expanded, serving to drive the turbine wheel and also to heat the catalytic element. To start the engine, one valve is closed, combustion is terminated in the catalytic combustor, and another valve is then opened to utilize air from the blower for the air driven motor. When the engine starts, the constituents in its exhaust gas react in the catalytic element and the heat generated provides additional energy for the turbine section.
NASA

N80-27695*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DYNAMIC ANALYSIS OF NONCONTACTING FACE SEALS
I. Etsion May 1980 40 p refs
(NASA-TM-79294; E-458) Avail: NTIS HC A03/MF A01 CSCL 11A

The dynamic behavior of a noncontacting coned face seal is analyzed taking into account various design parameters and operating conditions. The primary seal ring motion is expressed by a set of nonlinear equations for three degrees of freedom. These equations, which are solved numerically, allow identification of two dimensionless groups of parameters that affect the seal dynamic behavior. Stability maps for various seals are presented. These maps contain a stable-to-unstable transition region in which the ring wobbles at half the shaft frequency. The effect of various parameters on seal stability is discussed and an empirical expression for critical stability is offered.
Author

N80-27696*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE RESPONSE OF TURBINE ENGINE ROTORS TO INTERFERENCE RUBS
Albert F. Kascak 1980 18 p refs Presented at Army Sci. Conf., West Point, N. Y., 17-19 Jun. 1980 Film Supplement number C-294 to this report is available on request from Chief, Management Services Division (5-5), National Aeronautics and Space Administration, Lewis Research Center, 21000 Brookpark Road, Cleveland, Ohio 44135
(NASA-TM-81518; AVRADCOM-TR-80-C-14; E-462) Avail: NTIS HC A02/MF A01 CSCL 21D

A method was developed for the direct integration of a rotor dynamics system experiencing a blade loss induced rotor rub. Both blade loss and rotor rub were simulated on a rotor typical of a small gas turbine. A small change in the coefficient of friction (from 0.1 to 0.2) caused the rotor to change from forward to backward whirl and to theoretically destroy itself in a few rotations. This method provides an analytical capability to study the susceptibility of rotors to rub induced backward whirl problems.
L.F.M.

N80-27697*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STRESSES AND DEFORMATIONS IN ELLIPTICAL CONTACTS
Bernard J. Hamrock 1980 19 p refs Lecture presented at Lulea Univ., Sweden, 24 Jul. - 16 Aug. 1980
(NASA-TM-81535; E-488) Avail: NTIS HC A02/MF A01 CSCL 13I

Topics presented deal with defining conformal and nonconformal surfaces, curvature sum and difference, and surface and subsurface stresses in elliptical contacts. Load-deflection relationships for nonconformal contacts are developed. The deformation within the contact is, among other things, a function of the ellipticity parameter and elliptic integrals of the first and second kinds. Simplified expressions that allow quick calculations of the deformation to be made simply from a knowledge of the applied load, the material properties, and the geometry of the contacting elements are presented.
L.F.M.

N80-27698*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FULLY FLOODED ELASTOHYDRODYNAMIC LUBRICATED ELLIPTICAL CONTACTS
Bernard J. Hamrock 1980 27 p refs Lecture presented at Lulea Univ., Sweden, 24 Jul. - 16 Aug. 1980
(NASA-TM-81543; E-497) Avail: NTIS HC A03/MF A01 CSCL 13I

Emphasis is on fully flooded, elastohydrodynamic lubricated, elliptical contacts. A fully flooded conjunction is one in which the film thickness is not significantly changed when the amount of lubricant is increased. A brief description of the relevant equations used in the elastohydrodynamic lubrication of elliptical contacts is given. The most important practical aspect of the elastohydrodynamic theory is the determination of the minimum film thickness within the contact. The maintenance of a fluid film of adequate magnitude is an essential feature of the correct operation of lubricated machine elements. The results presented show the influence of contact geometry on minimum film thickness as expressed by the ellipticity parameter and the dimensionless speed, load, and materials parameters. Film thickness equations are developed for materials of high elastic modulus, such as metal, and for materials of low elastic modulus, such as rubber. In addition to the film thickness equations that are developed, plots of pressure and film thickness are presented. These theoretical solutions for film thickness have all the essential features of previously reported experimental observations based on optical interferometry. Correlation between theory and experiments is also presented.
L.F.M.

N80-27699*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STARVED ELASTOHYDRODYNAMIC LUBRICATED ELLIPTICAL CONTACTS
Bernard J. Hamrock 1980 23 p refs Lecture presented at Lulea Univ., Sweden, 24 Jul. - 16 Aug. 1980
(NASA-TM-81549; E-507) Avail: NTIS HC A02/MF A01 CSCL 13I

A theoretical study of the influence of lubricant starvation on film thickness and pressure in hard and soft elliptical elastohydrodynamic contacts is presented. From the results for both hard and soft EHL contacts a simple and important dimensionless inlet boundary distance is specified. This inlet boundary defines whether a fully flooded or a starved condition exists in the contact. Furthermore it is found that the film thickness for a starved condition could be written in dimensionless terms as a function of the inlet distance parameter and the film thickness for a fully flooded condition. Contour plots of pressure and film thickness in and around the contact are shown for fully flooded and starved conditions. The theoretical findings are compared directly with results obtained experimentally. Author

N80-28711* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CIRCUMFERENTIAL SHAFT SEAL Patent
Lawrence P. Ludwig, inventor (to NASA) Issued 15 Jul. 1980 4 p Filed 31 Mar. 1976 Supersedes N76-20488 (14-11, p 1394)
(NASA-Case-LEW-12119-1; US-Patent-4,212,477; US-Patent-Appl-SN-672219; US-Patent-Class-277-193; US-Patent-Class-277-153; US-Patent-Class-277-224) Avail: US Patent and Trademark Office CSCL 11A

A circumferential shaft seal is described which comprises two sealing rings held to a rotating shaft by means of a surrounding elastomeric band. The rings are segmented and are of a rigid sealing material such as carbon or a polyimide and graphite fiber composite.
Official Gazette of the U.S. Patent and Trademark Office

N80-28716*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
KINEMATIC CORRECTION FOR ROLLER SKEWING
Michael Savage (Akron Univ.) and Stuart H. Loewenthal Oct. 1980 46 p refs Proposed for presentation at 16th Bien. Mech. Conf., Beverly Hills, Calif., 29 Sep. - 1 Oct. 1980; sponsored by ASME
(NASA-TM-81564; E-526) Avail: NTIS HC A03/MF A01 CSCL 13I

A theory of kinematic stabilization of rolling cylinders is developed for high-speed cylindrical roller bearings. This stabilization requires race and roller crowning to product changes in the rolling geometry as the roller shifts axially. These changes put a reverse skew in the rolling elements by changing the rolling taper. Twelve basic possible bearing modifications are identified in this paper. Four have single transverse convex curvature in the rollers while eight have rollers with compound transverse curvature composed of a central cylindrical band of constant radius surrounded by symmetric bands with both slope and transverse curvature. Author

N80-29706*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ROTORDYNAMIC INSTABILITY PROBLEMS IN HIGH-PERFORMANCE TURBOMACHINERY
1980 463 p refs Conf. held at College Station, 12-14 May 1980; sponsored by Texas A and M Univ., Louisville Univ., and AROD
(NASA-CP-2133; E-413) Avail: NTIS HC A20/MF A01 CSCL 13I

Diagnostic and remedial methods concerning rotordynamic instability problems in high performance turbomachinery are discussed. Instabilities due to seal forces and work-fluid forces are identified along with those induced by rotor bearing systems. Several methods of rotordynamic control are described including active feedback methods, the use of elastometric elements, and the use of hydrodynamic journal bearings and supports. For individual titles, see N80-29707 through N80-29733.

N80-29716*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DAMPING IN RING SEALS FOR COMPRESSIBLE FLUIDS
David P. Fleming *In its* Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 169-188 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

An analysis is presented to calculate damping in ring seals for a compressible fluid. Results show that damping in tapered ring seals (optimized for stiffness) is less than that in straight bore ring seals for the same minimum clearance. Damping in ring seals can promote fractional frequency whirl and can, thus, be detrimental. Thus, tapered seals can benefit rotor and seal stability by having lower damping as well as higher stiffness. Use of incompressible results leads to large errors. Author

N80-29734*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LUBRICATION OF OPTIMIZED-DESIGN TAPERED-ROLLER BEARINGS TO 2.4 MILLION DN
Richard J. Parker and Stanley I. Pinel Aug. 1980 18 p refs Sponsored in part by Industrial Tectonics, Inc., Compton, Calif.
(NASA-TP-1714; E-270) Avail: NTIS HC A02/MF A01 CSCL 13I

The performance of 120.65 mm (4.75 in.) bore high speed design, tapered roller bearings was investigated at shaft speeds to 20,000 rpm (2.4 million DN) under combined thrust and radial load. The test bearing design was computer optimized for high speed operation. Temperature distribution bearing heat generation were determined as a function of shaft speed, radial and thrust loads, lubricant flow rates, and lubricant inlet temperature. The high speed design, tapered roller bearing operated successfully at shaft speeds up to 20,000 rpm under heavy thrust and radial loads. Bearing temperatures and heat generation with the high speed design bearing were significantly less than those of a modified standard bearing tested previously. Cup cooling was effective in decreasing the high cup temperatures to levels equal to the cone temperature. Author

N80-29735*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FILM THICKNESS FOR DIFFERENT REGIMES OF FLUID-FILM LUBRICATION
Bernard J. Hamrock 1980 14 p refs Presented at lecture series at Lulea, Sweden, 24 Jul. - 16 Aug. 1980
(NASA-TM-81550; E-508) Avail: NTIS HC A02/MF A01 CSCL 11H

Film thickness equations are provided for four fluid-film lubrication regimes found in elliptical contacts. These regimes are isoviscous-rigid; viscous-rigid; elastohydrodynamic lubrication of low-elastic-modulus materials (soft EHL), or isoviscous-elastic; and elastohydrodynamic lubrication of high-elastic-modulus materials (hard EHL), or viscous-elastic. The influence or lack of influence of elastic and viscous effects is the factor that distinguishes these regimes. The results are presented as a map of the lubrication regimes, with film thickness contours on a log-log grid of the viscosity and elasticity for three values of the ellipticity parameter. E.D.K.

N80-31790* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FREE-PISTON REGENERATIVE HOT GAS HYDRAULIC ENGINE Patent
Donald G. Beremand, inventor (to NASA) Issued 5 Aug. 1980 7 p Filed 12 Oct. 1978 Supersedes N79-10426 (17 - 12, p 0057)
(NASA-Case-LEW-12274-1; US-Patent-4,215,548; US-Patent-Appl-SN-950876; US-Patent-Class-60-520; US-Patent-Class-417-383) Avail: US Patent and Trademark Office CSCL 13I

A displacer piston which is driven pneumatically by a high-pressure or low-pressure gas is included in a free-piston regenerative hydraulic engine. Actuation of the displacer piston circulates the working fluid through a heater, a regenerator and a cooler. The present invention includes an inertial mass such as a piston or a hydraulic fluid column to effectively store and supply energy during portions of the cycle. Power is transmitted from the working fluid to a hydraulic fluid across a diaphragm or lightweight piston to achieve a hydraulic power out-put. The displacer piston of the present invention may be driven pneumatically, hydraulically or electromagnetically. In addition, the displacer piston and the inertial mass of the present invention may be positioned on the same side of the diaphragm member or may be separated by the diaphragm member.
Official Gazette of the U.S. Patent and Trademark Office

N80-31797*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SIMULATION AND VISUALIZATION OF FACE SEAL MOTION STABILITY BY MEANS OF COMPUTER GENERATED MOVIES
I. Etsion and B. M. Auer 1980 19 p refs Proposed for presentation at the Fluid Sealing Conf., Leeuwenhorst, Holland, 1-3 Apr. 1980; sponsored by the British Hydrodynamic Research Assoc.
(NASA-TM-81581; E-554) Avail: NTIS HC A02/MF A01 CSCL 13I

A computer aided design method for mechanical face seals is described. Based on computer simulation, the actual motion of the flexibly mounted element of the seal can be visualized. This is achieved by solving the equations of motion of this element, calculating the displacements in its various degrees of freedom vs. time, and displaying the transient behavior in the form of a motion picture. Incorporating such a method in the design phase allows one to detect instabilities and to correct undesirable behavior of the seal. A theoretical background is presented. Details of the motion display technique are described, and the usefulness of the method is demonstrated by an example of a noncontacting conical face seal. M.G.

N80-31798*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OBSERVATION OF PRESSURE VARIATION IN THE CAVITATION REGION OF SUBMERGED JOURNAL BEARINGS
I. Etsion and L. P. Ludwig 1980 27 p refs Proposed for presentation at the Lubrication Conf., New Orlenas, 11-14 Oct. 1981; sponsored by the ASME
(NASA-TM-81582; E-555) Avail: NTIS HC A03/MF A01 CSCL 13I

Visual observations and pressure measurements in the cavitation zone of a submerged journal bearing are described. Tests were performed at various shaft speeds and ambient pressure levels. Some photographs of the cavitation region are presented showing strong reverse flow at the downstream end of the region. Pressure profiles are presented showing significant pressure variations inside the cavitation zone, contrary to common assumptions of constant cavitation pressure. Author

N80-33749*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF CAGE DESIGN ON CHARACTERISTICS OF HIGH-SPEED-JET-LUBRICATED 35-MILLIMETER-BORE BALL BEARING
Fredrick T. Schuller, Stanley I. Pinel (Industrial Tectonics, Compton, Calif.), and Hans R. Signer (Industrial Tectonics, Compton, Calif.) Oct. 1980 13 p refs
(NASA-TP-1732; E-289) Avail: NTIS HC A02/MF A01 CSCL 13I

Parametric tests were conducted with a 35 mm bore angular contact ball bearing with a double outer land guided cage. Provisions were made for jet lubrication and outer-ring cooling of the bearing. Test conditions included a combined thrust and radial load at nominal shaft speeds of 48,000 rpm, and an oil-in temperature of 394 K (250 F). Successful operation of the test bearing was accomplished up to 2.5 million DN. Test results were compared with those obtained with similar bearing having a single outer land guided cage. Higher temperatures were generated with the double outer land guided cage bearing, and bearing power loss and cage slip were greater. Cooling the outer ring resulted in a decrease in overall bearing operating temperature. Author

A80-10040 * # **Survey of ion plating sources.** T. Spalvins (NASA, Lewis Research Center, Cleveland, Ohio). *American Vacuum Society, National Vacuum Symposium, 26th, New York, N.Y., Oct. 2-5, 1979, Paper.* 23 p. 35 refs.

Ion plating is a plasma deposition technique where ions of the gas and the evaporant have a decisive role in the formation of a coating in terms of adherence, coherence, and morphological growth. The range of materials that can be ion plated is predominantly determined by the selection of the evaporation source. Based on the type of evaporation source, gaseous media and mode of transport, the following will be discussed: resistance, electron beam sputtering, reactive and ion beam evaporation. Ionization efficiencies and ion energies in the glow discharge determine the percentage of atoms which are ionized under typical ion plating conditions. The plating flux consists of a small number of energetic ions and a large number of energetic neutrals. The energy distribution ranges from thermal energies up to a maximum energy of the discharge. The various reaction mechanisms which contribute to the exceptionally strong adherence - formation of a graded substrate/coating interface are not fully understood, however the controlling factors are evaluated. The influence of process variables on the nucleation and growth characteristics are illustrated in terms of morphological changes which affect the mechanical and tribological properties of the coating. (Author)

A80-13068 * # **NASA gear research and its probable effect on rotorcraft transmission design.** E. V. Zaretsky, D. P. Townsend, and J. J. Coy (NASA, Lewis Research Center, Cleveland, Ohio). *American Helicopter Society, Meeting on Helicopter Propulsion Systems, Williamsburg, Va., Nov. 6-8, 1979, Paper.* 17 p. 42 refs.

The NASA Lewis Research Center devised a comprehensive gear technology research program beginning in 1969, the results of which are being integrated into the NASA civilian Helicopter Transmission System Technology Program. Attention is given to the results of this gear research and those programs which are presently being undertaken. In addition, research programs studying pitting fatigue, gear steels and processing, life prediction methods, gear design and dynamics, elastohydrodynamic lubrication, lubrication methods and gear noise are presented. Finally, the impact of advanced gear research technology on rotorcraft transmission design is discussed. M.E.P.

A80-14727 * **Some flow characteristics of conventional and tapered high-pressure-drop simulated seals.** R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Dayton, Ohio, Oct. 16-18, 1979, ASLE Preprint 79-LC-3B-2.* 6 p. 11 refs.

The leak rates through shaft seals with large pressure drops were simulated using gaseous hydrogen, or nitrogen flowing through an annulus with a nonrotating centerbody. The flows were choked. For concentric or eccentric position of the rotor and parallel or convergent tapered flow passages, data and analysis revealed that mass flux or leak rate can be determined from a relation whose normalizing parameters depend on the thermodynamic critical constants of the working fluid and an average flow area expressed in terms of the inlet and exit cross-sectional areas. Using these normalized relations, the flow data for parallel and three convergent, tapered, shaft-seal configurations are in good agreement. Generalization to any simple gas or gas mixtures is implied and demonstrated in part. (Author)

A80-14734 * **The friction and wear of metals and binary alloys in contact with an abrasive grit of single-crystal silicon carbide.** K. Miyoshi and D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Dayton, Ohio, Oct. 16-18, 1979, ASLE Preprint 79-LC-5C-1.* 10 p. 19 refs.

Sliding friction experiments were conducted with various metals and iron-base binary alloys (alloying elements Ti, Cr, Mn, Ni, Rh, and W) in contact with single-crystal silicon carbide riders. Results indicate that the coefficient of friction and groove height (corresponding to the wear volume) decrease linearly as the shear strength of the bulk metal increases. The coefficient of friction and groove height generally decrease with an increase in solute content of binary alloys. A separate correlation exists between the solute to iron atomic radius ratio and the decreasing rates of change of coefficient of friction and groove height with increasing solute content. These rates of change are minimum at a solute to iron radius ratio of unity. They increase as the atomic ratio increases or decreases linearly from unity. The correlations indicate that atomic size is an important parameter in controlling friction and wear of alloys. (Author)

A80-15736 * # **Design of elastomer dampers for a high-speed flexible rotor.** J. A. Tecza, A. J. Smalley (Mechanical Technology, Inc., Latham, N.Y.), M. S. Darlow, and R. E. Cunningham (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Design Engineering Technical Conference, St. Louis, Mo., Sept. 10-12, 1979, Paper 79-DET-88* 9 p. 26 refs. Members, $1.50; nonmembers, $3.00. NASA-sponsored research.

This paper describes the methods used to design elastomerically damped supports for high-speed, flexible rotor-bearing systems. The procedure consists of using a damped natural frequency analysis to identify stiffness and damping requirements for the supports over the speed range. Optimum values for these coefficients are found and unbalance response analysis is used to calculate expected rotor behavior. Equations for calculating the shear and compressive stiffness and damping of button-type elastomer mounts are given, as is a procedure for their application to the design of the elastomeric mounts. These techniques were successfully applied to the design of damped elastomeric supports for a high-speed rotor, which traverses two bending critical speeds. Results of the testing showed that the rotor was well behaved and showed linear response to unbalance. Measured modal damping exceeded expectations and tests were conducted with both high- and low-loss elastomers, enabling the exploration of the practical range of elastomer damping capability. (Author)

A80-24002 * # **Dynamic properties of elastomer cartridge specimens under a rotating load.** M. S. Darlow, A. J. Smalley (Mechanical Technology, Inc., Latham, N.Y.), and R. E. Cunningham (NASA, Lewis Research Center, Cleveland, Ohio). In: World Congress on the Theory of Machines and Mechanisms, 5th, Montreal, Canada, July 8-13, 1979, Proceedings. Volume 2. (A80-23976 08-37) New York, American Society of Mechanical Engineers, 1979, p. 1599-1602.

This paper presents the results of a program of analysis and test to determine the dynamic properties of elastomer cartridges operating under a rotating load. These measured properties were compared to predictions based on results of unidirectional tests with the same elastomer material. The test method for the dynamic stiffness and damping measurements was essentially the same as the Base Excitation Resonant Mass Method. The primary difference is that the exciting force used for these most recent tests was exerted by rotating unbalance in a rotational test rig rather than a shake table. The specimens tested were: two rectangular cross-section, continuous ring cartridges of different cross-section and three cylindrical button cartridges of different button thickness. Tests were performed for strains from about 0.0001 to about 0.01 (double amplitude). Material properties and prediction equations determined from reciprocating tests were used to make numerical predictions of stiffness, damping, and loss coefficient for the test elements, with encouraging results. Strain was shown to be an important parameter in determining these dynamic properties, particularly damping and loss coefficient. (Author)

A80-28010 * **Wear of seal materials used in aircraft propulsion systems.** R. C. Bill (U.S. Army, Army Aviation Research and Development Center, Cleveland, Ohio) and L. P. Ludwig (NASA, Lewis Research Center, Cleveland, Ohio). *(U.S. Navy, Workshop on Thermal Deformation, Annapolis, Md., June 19, 20, 1979.) Wear,* vol. 59, Mar. 1, 1980, p. 165-189. 23 refs.

A review of various types of seal locations in a gas turbine engine and the significance of wear for each type are presented. Material selection guidelines and the PV (contact pressure times sliding velocity) criteria for seal materials are discussed, and examples of wear mechanisms in positive contact seals are given. It is suggested that improved wear, erosion, and oxidation resistant materials will be required for improved seal durability; finally, a correlation is proposed between wear characteristics and a factor that includes material strength, ductility, specific heat and hot-working temperature to attain low porosity metallic gas path seal materials. A.T.

A80-31961 * **Rolling-element bearings.** W. J. Anderson (NASA, Lewis Research Center, Mechanical Components Branch, Cleveland, Ohio). In: Tribology: Friction, lubrication, and wear. (A80-39154 12-37) Washington, D.C., Hemisphere Publishing Corp., 1980, p. 397-426. 16 refs.

In contrast to hydrodynamic bearings, which depend for low-friction characteristics on a fluid film between the journal and the bearing surfaces, roller-element bearings employ a number of balls or rollers that roll in an annular space. The paper briefly outlines the advantages and disadvantages of roller-element bearings as compared to hydrodynamic bearings. The discussion covers bearing types, rolling friction, friction losses in rolling bearings, contact stresses, deformations, kinematics (normal and high speeds), bearing dynamics including elastohydrodynamics, load distribution, lubrication (grease, solid oil, oil-air mist), specific dynamic capacity and life, specific static capacity, and fatigue or wearout (elastohydrodynamics, wear). Rolling bearing wear factor as a function of operating environment is plotted and discussed. S.D.

A80-42256 * # **Balancing of a power-transmission shaft with the application of axial torque.** E. S. Zorzi (Mechanical Technology, Inc., Latham, N.Y.) and D. Flemming (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-143.* 5 p. 6 refs. Members, $1.50; nonmembers, $3.00. NASA-supported research.

Evaluation of power transmission shafting for high-speed balancing has shown that when axial torque is applied, the imbalance response is altered. An increase in synchronous excitation always occurs if the axial torque level is altered from the value used during balancing; this was the case even when the shaft was balanced with torque applied. The twisting of the long slender shaft produces a change in the imbalance distribution sufficient to disrupt the balanced state. This paper presents a review of the analytic development of a weighted least squares approach to influence coefficient balancing and a review of experimental results. The analytic approach takes advantage of the fact that the past testing has shown that the influence coefficients are not significantly affected by the application of axial torque. The 3.60-m (12-ft) long aluminum shaft, 7.62 cm (3 in.) in diameter was run through the first flexural critical speed at torque levels ranging from zero-torque to 903.8 N-M (8000 lb-in.) in 112.9 N-M (1000 lb-in.) increments. Good comparison was achieved between predicted and experimental results. (Author)

A80-42272 * # **Elastomer damper performance - A comparison with a squeeze film for a supercritical power transmission shaft.** E. S. Zorzi, G. Burgess (Mechanical Technology, Inc., Latham, N.Y.), and R. Cunningham (NASA, Lewis Research Center, Latham, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-13, 1980, Paper 80-GT-162.* 7 p. 7 refs. Members, $1.50; nonmembers, $3.00.

This paper describes the design and testing of an elastomer damper on a super-critical power transmission shaft. The elastomers were designed to provide acceptable operation through the fourth bending mode and to control synchronous as well as nonsynchronous vibration throughout the operating range. The design of the elastomer was such that it could be incorporated into the system as a replacement for a squeeze-film damper without a reassembly, which could have altered the imbalance of the shaft. This provided a direct comparison of the elastomer and squeeze-film dampers without having to assess the effect of shaft imbalance changes. (Author)

A80-43159 * **An investigation into the role of adhesion in the erosion of ductile metals.** W. A. Brainard and J. Salik (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers, Annual Meeting, 35th, Anaheim, Calif., May 5-8, 1980, Preprint 80-AM-3E-3.* 5 p. 20 refs.

Existing theories of erosion of ductile metals based on cutting and deformation mechanisms predict no material removal at normal incidence which is contradictory to experience. Thus, other mechanisms may be involved. The possible role of adhesive material transfer during erosion is investigated by both single-particle impingement experiments and erosion by streams of particles. Examination of the rebounding particles as well as the eroded surfaces yields evidence of a significant adhesive mechanism for the ductile metals investigated. (Author)

A80-43163 * **Mechanisms of lubrication and wear of a bonded solid-lubricant film.** R. L. Fusaro (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers, Annual Meeting, 35th, Anaheim, Calif., May 5-8, 1980, Preprint 80-AM-3E-1.* 12 p. 6 refs.

The tribological properties of polyimide-bonded graphite fluoride films were investigated. A pin-on-disk type of testing apparatus was used; in addition to sliding a hemispherically tipped rider, a rider with a 0.95-mm-diameter flat area was slid against the film so that a lower, less variable contact stress could be achieved. Two stages of lubrication occurred: in the first, the film supported the load and the lubricating mechanism consisted of the shear of a thin surface layer between the rider and the bulk of the film. The second occurred after the bonded film had worn to the substrate, and consisted of the shear of very thin lubricant films between the rider and flat plateaus generated on the metallic substrate asperities. The film wear mechanism was strongly dependent on contact stress. (Author)

A80-43167 * **Analysis of wear debris from full-scale bearing fatigue tests using the Ferrograph.** W. R. Jones, Jr. and S. H. Loewenthal (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers, Annual Meeting, 35th, Anaheim, Calif., May 5-8, 1980, Preprint 80-AM-3E-2.* 7 p. 16 refs.

The Ferrograph was used to determine the types of quantities of wear particles generated during full-scale bearing fatigue tests. Deep-groove ball bearings made from AISI 52100 steel were used. A MIL-L-23699 tetraester lubricant was used in a recirculating lubrication system containing a 49-micron absolute filter. Test conditions included a maximum Hertz stress of 2.4 GPa, a shaft speed of 15,000 rpm and a lubricant supply temperature of 74 C (165 F). Four fatigue failures were detected by accelerometers in this test set. In general, the Ferrograph was more sensitive (up to 23 h) in detecting spall initiation than either accelerometers or the normal spectrographic oil analysis (SOAP). Four particle types were observed: normal rubbing wear particles, spheres, nonferrous particles, and severe wear (spall) fragments. (Author)

A80-43176 * **Friction and wear of plasma-sprayed coatings containing cobalt alloys from 25 deg to 650 deg in air.** H. E. Sliney and T. P. Jacobson (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers, Annual Meeting, 35th, Anaheim, Calif., May 5-8, 1980, Preprint 80-AM-6C-2.* 6 p. 13 refs.

Four different compositions of self-lubricating, plasma-sprayed, composite coatings with calcium fluoride dispersed throughout cobalt alloy-silver matrices were evaluated on a friction and wear apparatus. In addition, coatings of the cobalt alloys alone and of one coating with a nickel alloy-silver matrix were evaluated for comparison. The wear specimens consisted of two, diametrically opposed, flat rub shoes sliding on the coated, cylindrical surface of a rotating disk. Two of the cobalt composite coatings gave a friction coefficient of about 0.25 and low wear at room temperature, 400 and 650 C. Wear rates were lower than those of the cobalt alloys alone or the nickel alloy composite coating. However, oxidation limited the maximum useful temperature of the cobalt composite coating to about 650 C compared to about 900 C for the nickel composite coating. (Author)

A80-44240 * # **Application of superalloy powder metallurgy for aircraft engines.** R. L. Dreshfield and R. V. Miner, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). *Metal Powder Industries Federation and American Powder Metallurgy Institute, International Powder Metallurgy Conference, Washington, D.C., June 22-27, 1980, Paper.* 19 p. 8 refs.

The results of the Materials for Advanced Turbine Engines (MATE) program initiated by NASA are presented. Mechanical properties comparisons are made for superalloy parts produced by as-HIP powder consolidation and by forging of HIP consolidated billets. The effect of various defects on the mechanical properties of powder parts are shown. V.T.

A80-46407 * # **Constrained fatigue life optimization of a NASVYTIS multiroller traction drive.** J. J. Coy (U.S. Army, Propulsion Laboratory, Cleveland, Ohio), D. A. Rohn, and S. H. Loewenthal (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, International Power Transmission and Gearing Conference, 3rd, San Francisco, Calif., Aug. 18-22, 1980, Paper.* 18 p. 15 refs.

A contact fatigue life analysis method for multiroller traction drives is presented. The method is based on the Lundberg-Palmgren analysis method for rolling element bearing life prediction, and also uses life adjustment factors for materials, processing, lubrication, and effect of traction. The analysis method is applied in an optimization study to the multiroller traction drive, consisting of a single-stage planetary configuration with two rows of stepped planet rollers of five rollers per row. The drive was approximately 25 centimeters in diameter by 11 centimeters long, having a nominal ratio of 15:1. The theoretically predicted drive life was 2510 hours at a nominal continuous power and speed of 74.6 kW (100 hp) and 75,000 rpm. (Author)

A80-46409 * # **Effect of geometry and operating conditions on spur gear system power loss.** N. E. Anderson (U.S. Army, Propulsion Laboratory, Cleveland, Ohio) and S. H. Loewenthal (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, International Power Transmission and Gearing Conference, 3rd, San Francisco, Calif., Aug. 18-22, 1980, Paper.* 29 p. 13 refs.

The results of an analysis of the effects of spur gear size, pitch, width and ratio on total mesh power loss for a wide range of speeds, torques and oil viscosities are presented. The analysis uses simple algebraic expressions to determine gear sliding, rolling and windage losses and also incorporates an approximate ball bearing power loss expression. The analysis shows good agreement with published data. Large diameter and fine-pitched gears had higher peak efficiencies but lower part-load efficiency. Gear efficiencies were generally greater than 98 percent except at very low torque levels. Tare (no-load) losses are generally a significant percentage of the full-load loss except at low speeds. (Author)

A80-46410 * # **Evaluation of a high performance fixed-ratio traction drive.** S. H. Loewenthal, D. A. Rohn (NASA, Lewis Research Center, Cleveland, Ohio), and N. E. Anderson (U.S. Army, Propulsion Laboratory, Cleveland, Ohio). *American Society of Mechanical Engineers, International Power Transmission and Gearing Conference, 3rd, San Francisco, Calif., Aug. 18-22, 1980, Paper.* 30 p. 21 refs.

The results of a test program to evaluate a compact, high performance, fixed-ratio traction drive are presented. This transmission, the Nasvytis Multiroller Traction Drive, is a fixed-ratio, single-stage planetary with two rows of stepped planet-rollers. Two versions of the drive were parametrically tested back-to-back at speeds to 73,000 rpm and power levels to 180 kW (240 hp). Parametric tests were also conducted with the Nasvytis drive retrofitted to an automotive gas turbine engine. The drives exhibited good performance, with a nominal peak efficiency of 94 to 96 percent and a maximum speed loss due to creep of approximately 3.5 percent. (Author)

A80-46411 * # **Endurance and failure characteristics of modified Vasco X-2, CBS 600 and AISI 9310 spur gears.** D. P. Townsend and E. V. Zaretsky (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, International Power Transmission and Gearing Conference, 3rd, San Francisco, Calif., Aug. 18-22, 1980, Paper.* 27 p. 15 refs.

Gear endurance tests and rolling-element fatigue tests were conducted to compare the performance of spur gears made from AISI 9310, CBS 600 and modified Vasco X-2 and to compare the pitting fatigue lives of these three materials. Gears manufactured from CBS 600 exhibited lives longer than those manufactured from AISI 9310. However, rolling-element fatigue tests resulted in statistically equivalent lives. Modified Vasco X-2 exhibited statistically equivalent lives to AISI 9310. CBS 600 and modified Vasco X-2 gears exhibited the potential of tooth fracture occurring at a tooth surface fatigue pit. Case carburization of all gear surfaces for the modified Vasco X-2 gears results in fracture at the tips of the gears. (Author)

A80-46412 * # **Analytical and experimental spur gear tooth temperature as affected by operating variables.** D. P. Townsend (NASA, Lewis Research Center, Cleveland, Ohio) and L. S. Akin (Western Gear Corp., Lynwood, Calif.). *American Society of Mechanical Engineers, International Power Transmission and Gearing Conference, 3rd, San Francisco, Calif., Aug. 18-22, 1980, Paper.* 27 p. 11 refs.

A gear tooth temperature analysis was performed using a finite element method combined with a calculated heat input, calculated oil jet impingement depth, and estimated heat transfer coefficients. Experimental measurements of gear tooth average surface temperatures and instantaneous surface temperatures were made with a fast response infrared radiometric microscope. Increased oil jet pressure had a significant effect on both average and peak surface temperatures at both high load and speeds. Increasing the speed at constant load and increasing the load at constant speed causes a significant rise in average and peak surface temperatures of gear teeth. The oil jet pressure required for adequate cooling at high speed and load conditions must be high enough to get full depth penetration of the teeth. Calculated and experimental results were in good agreement with high oil jet penetration but showed poor agreement with low oil jet penetration depth. (Author)

A80-46413 * # **Simplified fatigue life analysis for traction drive contacts.** D. A. Rohn, S. H. Loewenthal (NASA, Lewis Research Center, Cleveland, Ohio), and J. J. Coy (U.S. Army, Propulsion Laboratory, Cleveland, Ohio). *American Society of Mechanical Engineers, International Power Transmission and Gearing Conference, 3rd, San Francisco, Calif., Aug. 18-22, 1980, Paper.* 28 p. 19 refs.

A simplified fatigue life analysis for traction drive contacts of arbitrary geometry is presented. The analysis is based on the Lundberg-Palmgren theory used for rolling-element bearings. The effects of torque, element size, speed, contact ellipse ratio, and the influence of traction coefficient are shown. The analysis shows that within the limits of the available traction coefficient, traction contacts exhibit longest life at high speeds. Multiple, load-sharing roller arrangements have an advantageous effect on system life, torque capacity, power-to-weight ratio and size. (Author)

N80-13474*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
FEASIBILITY OF SiC COMPOSITE STRUCTURES FOR 1644 DEG GAS TURBINE SEAL APPLICATIONS Final Report, 28 Apr. - 30 May 1979
R. Darolia May 1979 109 p ref
(Contract NAS3-20082)
(NASA-CR-159597; R79AEG625) Avail: NTIS HC A06/MF A01 CSCL 11A

The feasibility of silicon carbide composite structures was evaluated for 1644 K gas turbine seal applications. The silicon carbide composites evaluated consisted of Si/SiC Silcomp (Trademark) - and sintered silicon carbide as substrates, both with attached surface layers containing BN as an additive. A total of twenty-eight candidates with variations in substrate type and density, and layer chemistry, density, microstructure, and thickness were evaluated for abradability, cold particle erosion resistance, static oxidation resistance, ballistic impact resistance, and fabricability. The BN-free layers with variations in density and pore size were later added for evaluation. The most promising candidates were evaluated for Mach 1.0 gas oxidation/erosion resistance from 1477 K to 1644 K. The as-fabricated rub layers did not perform satisfactorily in the gas oxidation/erosion tests. However, preoxidation was found to be beneficial in improving the hot gas erosion resistance. Overall, the laboratory and rig test evaluations show that material properties are suitable for 1477 K gas turbine seal applications. J.M.S.

N80-15411*# Detroit Diesel Allison, Indianapolis, Ind.
PLASMA-SPRAYED DUAL DENSITY CERAMIC TURBINE SEAL SYSTEM Final Report
D. L. Clingman, B. Schechter, K. R. Cross, and J. R. Cavanagh Oct. 1979 67 p refs
(Contract NAS3-21263)
(NASA-CR-159739; EDR-10085) Avail: NTIS HC A04/MF A01 CSCL 11A

Dual density, plasma sprayed ceramic coating systems were investigated for possible application as abradable turbine tip seal systems in small gas turbine engines. Abradability, erosion resistance, internal leakage, and microstructural characterization were investigated for polyester and cenosphere filled zirconium oxide composites. Results indicate the polyester system is more abradable but displays significantly less erosion resistance than the cenosphere system. It is also stated that the absence of significant blade tip damage during abradability testing of both systems suggests additional effort may result in a more nearly optimum balance of abradability and erosion resistance. M.G.

N80-16338*# General Electric Co., Cincinnati, Ohio. Materials and Process Technology Labs.
PROGRAM TO DEVELOP SPRAYED, PLASTICALLY DEFORMABLE COMPRESSOR SHROUD SEAL MATERIALS Interim Technical Progress Report, 29 Jun. 1976 - 28 Feb. 1979
R. C. Schwab Nov. 1979 78 p refs
(Contract NAS3-20054)
(NASA-CR-159741; ITPR-1) Avail: NTIS HC A05/MF A01 CSCL 11A

A study of fundamental rub behavior for ten dense sprayed materials and eight current compressor clearance materials has been conducted. A literature survey of a wide variety of metallurgical and thermophysical properties was conducted and correlated to rub behavior. Based on these results, the most promising dense rub material was Cu-9Al. Additional studies on the effects of porosity, incursion rate, blade solidity and ambient temperature were carried out on aluminum bronze (Cu-9Al-1Fe) with and without a 515B Feltmetal underlayer. Author

N80-17470*# Chrysler Corp., Detroit, Mich.
MATERIALS REVIEW FOR IMPROVED AUTOMOTIVE GAS TURBINE ENGINE Final Report
C. Belleau, W. L. Ehlers, and F. A. Hagen Apr. 1978 101 p refs Sponsored by NASA
(Contract EY-76-C-02-2749,A011)
(NASA-CR-159673; DOE/NASA/2749-79/4 Vol-4) Avail: NTIS HC A06/MF A01 CSCL 21A

The potential role of superalloys, refractory alloys, and ceramics in the hottest sections of engines operating with turbine

inlet temperatures as high as 1370 C is examined. The conventional superalloys, directionally solidified eutectics, oxide dispersion strenghened alloys, and tungsten fiber reinforced superalloys are reviewed and compared on the basis of maximum turbine blade temperature capability. Improved high temperature protective coatings and special fabrication techniques for these advanced alloys are discussed. Chromium, columbium, molybdenum, tantalum, and tungsten alloys are also reviewed. Molbdenum alloys are found to be the most suitable for mass produced turbine wheels. Various forms and fabrication processes for silicon nitride, silicon carbide, and SIALON's are investigated for use in highstress and medium stress high temperature environments.
K.L.

N80-18402*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
IMPROVED TIRE/WHEEL CONCEPT Patent Application
Philip M. Harper, Sr., inventor (to NASA) (Boeing Commercial Airplane Co., Seattle, Wash.) Filed 12 Dec. 1979 12 p
Sponsored by NASA
(NASA-Case-LAR-11695-2; US-Patent-Appl-SN-103836) Avail: NTIS HC A02/MF A01 CSCL 01C

A tire and wheel assembly is described which consists of a low profile pneumatic tire with sidewalls that deflect inwardly under a load and a wheel having a narrow central channel and extended rim flanges. The extended rim flanges support the tire sidewalls under static and dynamic loading conditions to produce a combination particularly suited to aircraft applications. NASA

N80-22700*# Boeing Commercial Airplane Co., Seattle, Wash.
TESTING OF RECIPROCATING SEALS FOR APPLICATION IN A STIRLING CYCLE ENGINE
J. F. Curulla and T. L. Beck Feb. 1980 76 p refs
(Contract NAS3-20612)
(NASA-CR-159820; DOE/NASA/0612-80/1;
BCAC-D6-48915) Avail: NTIS HC A05/MF A01 CSCL 11A

Six single stage reciprocating seal configurations to the requirements of the Stirling cycle engine were evaluated. The seals tested were; the Boeing Footseal, NASA Chevron polyimide seal, Bell seal, Quad seal, Tetraseal, and Dynabak seal. None of these seal configurations met the leakage goals of .002 cc/sec at helium gas pressure of 1.22 x 10 to the 7th power PA, rod speed of 7.19 m/sec peak, and seal environmental temperature of 408 K for 1500 hours. Most seals failed due to high temperatures. Catastrophic failures were observed for a minimum number of test runs characterized by extremely high leakage rates and large temperature rises. The Bell seal attained 63 hours of run time at significantly lowered test conditions. E.D.K.

N80-22702*# Kumm (Emerson L.), Tempe, Ariz.
DESIGN STUDY OF FLAT BELT CVT FOR ELECTRIC VEHICLES
Emerson L. Kumm Mar. 1980 159 p refs
(Contract DEN3-114; Contract EC-77-A-31-1044)
(NASA-CR-159822; P-1006) Avail: NTIS HC A08/MF A01 CSCL 13I

A continuously variable transmission (CVT) was studied, using a novel flat belt pulley arrangement which couples the high speed output shaft of an energy storage flywheel to the drive train of an electric vehicle. A specific CVT arrangement was recommended and its components were selected and sized, based on the design requirements of a 1700 KG vehicle. A design layout was prepared and engineering calculations made of component efficiencies and operating life. The transmission efficiency was calculated to be significantly over 90% with the expected vehicle operation. A design consistent with automotive practice for low future production costs was considered, together with maintainability. The technology advancements required to develop the flat belt CVT were identified and an estimate was made of how the size of the flat belt CVT scales to larger and smaller design output torques. The suitability of the flat belt CVT for alternate application to an electric vehicle powered by an electric motor without flywheel and to a hybrid electric vehicle powered by an electric motor with an internal combustion engine was studied. E.D.K.

N80-25661*# AiResearch Mfg. Co., Torrance, Calif.
DESIGN STUDY OF TOROIDAL TRACTION CVT FOR ELECTRIC VEHICLES Final Report
A. E. Raynard, James Kraus, and Daniel D. Bell Jan. 1980 161 p refs
(Contracts DEN3-117; EC-77-A-31-1044)
(NASA-CR-159803; DOE/NASA/0117-80/1; Rept-80-16762) Avail: NTIS HC A08/MF A01 CSCL 13I

The development, evaluation, and optimization of a preliminary design concept for a continuously variable transmission (CVT) to couple the high-speed output shaft of an energy storage flywheel to the drive train of an electric vehicle is discussed. An existing computer simulation program was modified and used to compare the performance of five CVT design configurations. Based on this analysis, a dual-cavity full-toroidal drive with regenerative gearing is selected for the CVT design configuration. Three areas are identified that will require some technological development: the ratio control system, the traction fluid properities, and evaluation of the traction contact performance. Finally, the suitability of the selected CVT design concept for alternate electric and hybrid vehicle applications and alternate vehicle sizes and maximum output torques is determined. In all cases the toroidal traction drive design concept is applicable to the vehicle system. The regenerative gearing could be eliminated in the electric powered vehicle because of the reduced ratio range requirements. In other cases the CVT with regenerative gearing would meet the design requirements after appropriate adjustments in size and reduction gearing ratio. M.G.

N80-24620*# Chrysler Corp., Detroit, Mich.
BASELINE AUTOMOTIVE GAS TURBINE ENGINE DEVELOPMENT PROGRAM Final Report
C. E. Wagner, ed. and R. C. Pampreen, ed. Apr. 1979 182 p refs Sponsored by NASA
(Contracts EY-76-C-02-2749; EC-77-A-31-1040)
(NASA-CR-159670; DOE/NASA/2749-79/1-Vol-1;
COO-2749-42) Avail: NTIS HC A09/MF A01 CSCL 21A

Tests results on a baseline engine are presented to document the automotive gas turbine state-of-the-art at the start of the program. The performance characteristics of the engine and of a vehicle powered by this engine are defined. Component improvement concepts in the baseline engine were evaluated on engine dynamometer tests in the complete vehicle on a chassis dynamometer and on road tests. The concepts included advanced combustors, ceramic regenerators, an integrated control system, low cost turbine material, a continuously variable transmission, power-turbine-driven accessories, power augmentation, and linerless insulation in the engine housing. R.E.S.

N80-24621*# Chrysler Corp., Detroit, Mich.
CONCEPTUAL DESIGN STUDY OF AN IMPROVED AUTOMOTIVE GAS TURBINE POWERTRAIN Final Report
C. E. Wagner, ed. and R. C. Pampreen, ed. Jun. 1979 196 p refs
(Contracts DE-AC02-76CS-52749)
(NASA-CR-159672; DOE/NASA/2749-79/3-Vol-3;
COO-2749-40) Avail: NTIS HC A09/MF A01 CSCL 21A

Automotive gas turbine concepts with significant technological advantages over the spark ignition (SI) engine were assessed. Possible design concepts were rated with respect to fuel economy and near-term application. A program plan which outlines the development of the improved gas turbine (IGT) concept that best met the goals and objectives of the study identifies the research and development work needed to meet the goal of entering a production engineering phase by 1983. The fuel economy goal is to show at least a 20% improvement over a conventional 1976 SI engine/vehicle system. On the basis of achieving the fuel economy goal, of overall suitability to mechanical design, and of automotive mass production cost, the powertrain selected was a single-shaft engine with a radial turbine and a continuously variable transmission (CVT). Design turbine inlet temperature was 1150 C. Reflecting near-term technology, the turbine rotor would be made of an advanced superalloy, and the transmission would be a hydromechanical CVT. With successful progress in long-lead R&D in ceramic technology and the belt-drive CVT, the turbine inlet temperature would be

1350 C to achieve near-maximum fuel economy. A.R.H.

N80-26662*# Rocketdyne, Canoga Park, Calif.
SMALL, HIGH PRESSURE LIQUID HYDROGEN TURBOPUMP Final Report, 7 Jun. 1977 - 26 Oct. 1979
A. Csomor and D. J. Warren 23 May 1980 234 p refs
(Contract NAS3-21008)
(NASA-CR-159821; RI/RD79-322) Avail: NTIS HC A11/MF A01 CSCL 13K

A high pressure, low capacity, liquid hydrogen turbopump was designed, fabricated, and tested. The design configuration of the turbopump is summarized and the results of the analytical and test efforts are presented. Approaches used to pin point the cause of poor suction performance with the original design are described and performance data are included with an axial inlet design which results in excellent suction capability. E.D.K.

N80-29707*# Phillips Petroleum Co. Europe-Africa, London (England).
FIELD EXPERIENCES WITH ROTORDYNAMIC INSTABILITY IN HIGH-PERFORMANCE TURBOMACHINERY
H. E. Doyle *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 3-13 (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

Two field situations illustrate the consequences of rotordynamic instability in centrifugal compressors. One involves the reinjection of produced gas into a North Sea oil formation for the temporary extraction of crude. The other describes on-shore compressors used to deliver natural gas from off-shore wells. The problems which developed and the remedies attempted in each case are discussed. Instability problems resulted in lost production, extended construction periods and costs, and heavy maintenance expenditures. The need for effective methods to properly identify the problem in the field and in the compressor design stage is emphasized. M.G.

N80-29708*# Southwest Research Inst., San Antonio, Tex.
FIELD VERIFICATION OF LATERAL-TORSIONAL COUPLING EFFECTS ON ROTOR INSTABILITIES IN CENTRIFUGAL COMPRESSORS
J. C. Wachel and F. R. Szenasi *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 15-34 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

Lateral and torsional vibration data obtained on a centrifugal compressor train which had shaft instabilities and gear failures is examined. The field data verifies that the stability of centrifugal compressors can be adversely affected by coincidence of torsional natural frequencies with lateral instability frequencies. The data also indicates that excitation energy from gear boxes can reduce stability margins if energy is transmitted either laterally or torsionally to the compressors. The lateral and torsional coupling mechanisms of shaft systems is discussed. The coupling mechanisms in a large industrial compressor train are documented and the potential effect on rotor stability is demonstrated. Guidelines are set forth to eliminate these potential problems by minimizing the interaction of torsional and lateral responses and their effect on rotor stability. M.G.

N80-29709*# Mechanical Technology, Inc., Latham, N. Y.
PRACTICAL EXPERIENCE WITH UNSTABLE COMPRESSORS
Stqan B. Malanoski *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 35-43 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01

Using analytical mathematical modeling techniques for the system components, an attempt is made to gauge the destabilizing effects in a number of compressor designs. In particular the overhung (or cantilevered) compressor designs and the straddle-mounted (or simply supported) compressor designs are examined. Recommendations are made, based on experiences with stable and unstable compressors, which can be used as guides in future designs. High and low pressure compressors which operate well above their fundamental rotor-bearing lateral natural frequencies can suffer from destructive subsynchronous vibration. Usually the elements in the system design which contribute to this vibration, other than the shafting and the bearings, are the seals (both gas labyrinth and oil breakdown bushings) and the aerodynamic components. M.G.

N80-29710*# Ingersoll-Rand Co., Easton, Pa.
ANALYSIS AND IDENTIFICATION OF SUBSYNCHRONOUS VIBRATION FOR A HIGH PRESSURE PARALLEL FLOW CENTRIFUGAL COMPRESSOR
R. G. Kirk, J. C. Nicholas, G. H. Donald, and R. C. Murphy *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 45-63 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The summary of a complete analytical design evaluation of an existing parallel flow compressor is presented and a field vibration problem that manifested itself as a subsynchronous vibration that tracked at approximately 2/3 of compressor speed is reviewed. The comparison of predicted and observed peak response speeds, frequency spectrum content, and the performance of the bearing-seal systems are presented as the events of the field problem are reviewed. Conclusions and recommendations are made as to the degree of accuracy of the analytical techniques used to evaluate the compressor design. M.G.

N80-29711*# Allis-Chalmers Mfg. Co., Milwaukee, Wis.
SUBSYNCHRONOUS INSTABILITY OF A GEARED CENTRIFUGAL COMPRESSOR OF OVERHUNG DESIGN
J. H. Hudson and L. J. Wittman *In* NASA. Lewis Res Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 67-83 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The original design analysis and shop test data are presented for a three stage (poster) air compressor with impellers mounted on the extensions of a twin pinion gear, and driven by an 8000 hp synchronous motor. Also included are field test data, subsequent rotor dynamics analysis, modifications, and final rotor behavior. A subsynchronous instability existed on a geared, overhung rotor. State-of-the-art rotor dynamics analysis techniques provided a reasonable analytical model of the rotor. A bearing modification arrived at analytically eliminated the instability. M.G.

N80-29712*# Bently Nevada Corp., Minden.
THE PARAMETERS AND MEASUREMENTS OF THE DESTABILIZING ACTIONS OF ROTATING MACHINES, AND THE ASSUMPTIONS OF THE 1950'S
Donald E. Bently *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 95-106 (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The measurability of destabilizing actions is demonstrated for a rotor built to produce a forward circular, self excited malfunction (gas whip). It is argued that the continued use of past modeling technqiues is unfortunate in that it has led to the use of inappropriate words to express what is happening and a lack of full understanding of the category of forward circular whip instability mechanisms. M.G.

N80-29713*# Kobe Steel Ltd. (Japan).
ASYNCHRONOUS VIBRATION PROBLEM OF CENTRIFUGAL COMPRESSOR
Takeshi Fujikawa, Naotsugi Ishiguro, and Mitsuhiko Ito *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 109-118 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

An unstable asynchronous vibration problem in a high pressure centrifugal compressor and the remedial actions against it are described. Asynchronous vibration of the compressor took place when the discharge pressure (Pd) was increased, after the rotor was already at full sppeed. The typical spectral data of the shaft vibration indicate that as the pressure Pd increases, pre-unstable vibration appears and becomes larger, and large unstable asynchronous vibration occurs suddenly (Pd ≈ 5.49MPa). A computer program was used which calculated the logarithmic decrement and the damped natural frequency of the rotor bearing systems. The analysis of the log-decrement is concluded to be effective in preventing unstable vibration in both the design stage and remedial actions. M.G.

N80-29714*# Louisville Univ., Ky. Mechanical Engineering Dept.

TESTING OF TURBULENT SEALS FOR ROTODYNAMIC COEFFICIENTS

Dara W. Childs, John B. Dressman and S. Bart Childs *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 121-138 refs Prepared in cooperation with Texas A and M Univ., College Station (For primary document see N80-29706 20-37)
(Grant NsG-3200)
Avail: NTIS HC A20/MF A01 CSCL 13I

A test program developed for dynamic testing of straight and convergent-tapered seals, with the capability of separately determining both direct and cross-coupled stiffness, damping, and added mass coefficients is described. The test apparatus causes the seal journal to execute small-eccentricity centered circular orbits within its bearings. Dynamic measurements are made and recorded of the seal-displacement-vector components, and of the pressure field. The pressure field is integrated to yield seal reaction force components. The displacement and force vector components are analyzed via a generalized Newton-Raphson procedure to yield the desired seal dynamic coefficients. Representative test data are provided and discussed. M.G.

N80-29715*# Kobe Univ. (Japan). Engineering Dept.

EVALUATION OF INSTABILITY FORCES OF LABYRINTH SEALS IN TURBINES OR COMPRESSORS

Tkuakuzo Iwatsubo *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 139-167 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The effects of a force induced by the labyrinth seal on the stability of rotor systems and the factors of the seal which affect the stability are investigated. In the analysis, it is assumed that the fluid in the seal is steady and that the rotor is set vertically in order to avoid the effects of gravity force. The force induced by the seal is expressed in terms proportional to the velocity and displacement of the rotor and is deduced to that expression for the oil film force in journal bearings. That force is taken into account in the equations of motion; then the stability of the system is discussed by energy concept. The force induced by the labyrinth seal always makes the rotor system unstable, and the tendency is marked when seal leakages are small. The resonance point of the rotor system is also affected by the labyrinth seal (the resonance point of the rotor system is removed by the seal leakages). The force induced by the labyrinth seal was measured by using a water-tunnel experimental system which was designed to measure the labyrinth seal force by using the similarity between gas and liquid flow theory. M.G.

N80-29717*# Stuttgart Univ. (West Germany). Institut fuer Thermische Stroemungsmaschinen.

FLOW INDUCED SPRING COEFFICIENTS OF LABYRINTH SEALS FOR APPLICATION IN ROTOR DYNAMICS

H. Benckert and J. Wachter *In* NASA. Lewis Res. Center Rotodyn. Instability Probl. in High-Performance Turbomachinery 1980 p 189-212 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

Flow induced aerodynamic spring coefficients of labyrinth seals are discussed and the restoring force in the deflection plane of the rotor and the lateral force acting perpendicularly to it are also considered. The effects of operational conditions on the spring characteristics of these components are examined, such as differential pressure, speed, inlet flow conditions, and the geometry of the labyrinth seals. Estimation formulas for the lateral forces due to shaft rotation and inlet swirl, which are developed through experiments, are presented. The utilization of the investigations is explained and results of stability calculations, especially for high pressure centrifugal compressors, are added. Suggestions are made concerning the avoidance of exciting forces in labyrinths. M.G.

N80-29718*# Hitachi Ltd., Tsuchiura (Japan). Mechanical Engineering Research Lab.

HYDRAULIC FORCES CAUSED BY ANNULAR PRESSURE SEALS IN CENTRIFUGAL PUMPS

T. Iino and H. Kaneko *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 213-225 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The hydraulic forces caused by annular pressure seals were investigated. The measured inlet and exit loss coefficients of the flow through the seals were much smaller than the conventional values. The results indicate that the damping coefficient and the inertia coefficient of the fluid film in the seal are not affected much by the rotational speed or the eccentricity of the rotor, though the stiffness coefficient seemed to be influenced by the eccentricity. R.C.T.

N80-29719*# California Inst. of Tech., Pasadena.

A TEST PROGRAM TO MEASURE FLUID MECHANICAL WHIRL-EXCITATION FORCES IN CENTRIFUGAL PUMPS

C. E. Brennen, A. J. Acosta, and T. K. Caughey *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 229-247 refs (For primary document see N80-29706 20-37)
(Contract NAS8-33108)
Avail: NTIS HC A20/MF A01 CSCL 13I

The details of a test program for the measurement of the unsteady forces on centrifugal impellers are discussed. Various hydrodynamic flows are identified as possible contributors to these destabilizing forces. R.C.T.

N80-29720*# Technical Univ. of Denmark, Copenhagen.

EFFECT OF FLUID FORCES ON ROTOR STABILITY OF CENTRIFUGAL COMPRESSORS AND PUMPS

Jorgen Colding-Jorgensen *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 249-265 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

A simple two dimensional model for calculating the rotordynamic effects of the impeller force in centrifugal compressors and pumps is presented. It is based on potential flow theory with singularities. Equivalent stiffness and damping coefficients are calculated for a machine with a vaneless volute formed as a logarithmic spiral. It is shown that for certain operating conditions, the impeller force has a destablizing effect on the rotor. R.C.T.

N80-29721*# Cornell Univ., Ithaca, N. Y.

NON-SYNCHRONOUS WHIRLING DUE TO FLUID-DYNAMIC FORCES IN AXIAL TURBO-MACHINERY ROTORS

Shan Fu Shen and Vinod G. Mengle *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 267-284 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The role of fluid forces acting on the blades of an axial turborotor with regards to whirling was analyzed. The dynamic equations were formulated for the coning mode of an overhung rotor. The exciting forces due to the motion were defined through a set of rotor stability derivatives, and analytical expressions of the aerodynamic contributions were found for the case of small mean stream deflection, high solidity and equivalent flat plate cascade. For a typical case, only backward whirl was indicated when the phase shifting of the rotor wake effect was ignored. A parametric study of the dynamic stability boundary reveals that a reduction in blade stagger angle, mass flow rate, fluid density and an increase in stiffness and external damping are all inducive for improved stability. R.C.T.

N80-29722*# Turbo Research, Inc., Lionville, Pa.
VIBRATION EXCITING MECHANISMS INDUCED BY FLOW IN TURBOMACHINE STAGES
William E. Thompson *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 285-302 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The quasisteady computer analysis of the perturbated centrifugal impeller passage flow was reviewed. A total of 115 stage calculations were used to define the fluid damping coefficient, delta sub fluid. Results indicate that the average total damping coefficient per stage needed for stability is delta sub total > 1.85. R.C.T.

N80-29723*# Technische Universitaet, Munich (West Germany). Institut fuer Thermische Kraftanlagen.
SELF-EXCITED ROTOR WHIRL DUE TO TIP-SEAL LEAKAGE FORCES
B. Leie and H.-J. Thomas *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 303-316 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The limitations in the performance of turbomachines which arise as a result of selfexcited vibration were investigated. Bearing forces, elastic hysteresis, and forces from fluid flow through clearances were considered as possible origins. A theoretical evaluation was made to determine the dependence of the forces form the leakage losses and from rotating flow in radial gaps. R.C.T.

N80-29724*# Tokyo Univ. (Japan).
FLUID FORCES ON ROTATING CENTRIFUGAL IMPELLER WITH WHIRLING MOTION
Hidenobu Shoji and Hideo Ohashi *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 317-328 refs Sponsored in part by the Japanese Ministry of Education and by Hitachi Ltd. (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

Fluid forces on a centrifugal impeller, whose rotating axis whirls with a constant speed, were calculated by using unsteady potential theory. Calculations were performed for various values of whirl speed, number of impeller blades and angle of blades. Specific examples as well as significant results are given. R.C.T.

N80-29725*# Heriott-Watt Univ., Edinburgh (Scotland). Mechanical Engineering Dept.
LIMIT CYCLES OF A FLEXIBLE SHAFT WITH HYDRODYNAMIC JOURNAL BEARINGS IN UNSTABLE REGIMES
R. David Brown and Henry F. Black *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 331-343 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

A symmetric 3 mass rotor supported on hydrodynamic bearings is described. An approximate method of representing finite bearings is used to calculate bearing forces. As the method sums forces from a number of independent circular lobes lemon 3 and 4 lobe bearings are taken into account. The calculations are based on an axial groove bearing. Linear analysis precedes nonlinear simulation of some unstable conditions. The demonstration of small limit cycles suggests that necessarily flexible rotors e.g., helicopter tail rotors, may be practical without either tilt pad bearings or external dampers. R.C.T.

N80-29726*# Sussex Univ., Brighton (England). School of Engineering and Applied Sciences.
ON THE ROLE OF OIL-FILM BEARINGS IN PROMOTING SHAFT INSTABILITY: SOME EXPERIMENTAL OBSERVATIONS
R. Holmes *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 345-357 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The occurrence of oil whirl instability in rigid and flexible rotor systems was investigated. The effect of various bearing parameters on the oil whirl frequency and amplitude of rigid and flexible shafts supported on fluid film bearings was also studied. R.C.T.

N80-29727*# Texas A&M Univ., College Station. Dept. of Mechanical Engineering.
EXPERIMENTAL RESULTS CONCERNING CENTRIFUGAL IMPELLER EXCITATIONS
J. M. Vance and F. J. Landadio *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 361-367 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The effect of working fluid on the dynamics of an impeller with radial vanes was investigated. The impeller was supported vertically from a very flexible quill shaft in order to produce a low critical speed, and to allow the fluid dynamic effects on the impeller to predominate. The shaft was supported from ball bearings, so that there was no possibility of oil whip from fluid film bearings as a destabilizing influence. The impeller was run both in the atmosphere, and submerged in working fluids contained in a cylindrical housing, open at the top. Variable speed was obtained with a dc gearmotor drive unit. The speed was measured with a proximity probe pulse tachometer and electronic digital counter. R.C.T.

N80-29728*# Massachusetts Inst. of Tech., Cambridge.
PHYSICAL EXPLANATIONS OF THE DESTABILIZING EFFECT OF DAMPING IN ROTATING PARTS
Stephen H. Crandall *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 369-382 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The destabilizing effect of rotating damping was investigated. When the rotation was faster than the whirl, rotating damping drags the orbiting particle forward. When stationary damping was also present, the stability borderline was readily determined by balancing the backward and forward drags. A key notion was that a forward whirl at rate omega a sub n with respect to stationary axes appears to be a backward whirl at rate Omega - omega sub n with respect to a system rotating supercritically at rate Omega. The growth rate of unstable whirls (or the decay rate of stable whirls was readily estimated by a simple energy balance. R.C.T.

N80-29729*# Politechnika Lodzka (Poland).
PARAMETRIC INSTABILITIES OF ROTOR-SUPPORT SYSTEMS WITH APPLICATION TO INDUSTRIAL VENTILATORS
Zdzislaw Parszewski, Tanusz Krodkiemski, and Krzysztof Marynowski *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 383-400 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

Rotor support systems interaction with parametric excitation is considered for both unequal principal shaft stiffness (generators) and offset disc rotors (ventilators). Instability regions and types of instability are computed in the first case, and parametric resonances in the second case. Computed and experimental results are compared for laboratory machine models. A field case study of parametric vibrations in industrial ventilators is reported. Computed parametric resonances are confirmed in field measurements, and some industrial failures are explained. Also the dynamic influence and gyroscopic effect of supporting structures are shown and computed. R.C.T.

N80-29730*# Virginia Univ., Charlottesville. Dept. of Mechanical and Aerospace Engineering.
INSTABILITY THRESHOLDS FOR FLEXIBLE ROTORS IN HYDRODYNAMIC BEARINGS
Paul E. Allaire and Ronald D. Flack *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 403-427 refs (For primary document see N80-29706 20-37)
(Grant NsG-3177; Contract DE-AC01-79ET-13151; Grant RC-A-77-6C)
Avail: NTIS HC A20/MF A01 CSCL 13I

Two types of fixed pad hydrodynamic bearings (multilobe and pressure dam) were considered. Optimum and nonoptimum geometric configurations were tested. The optimum geometric configurations were determined by using a theoretical analysis and then the bearings were constructed for a flexible rotor test rig. It was found that optimizing bearings using this technique produces a 100% or greater increase in rotor stability. It is shown that this increase in rotor stability is carried out in the absence of certain types of instability mechanisms such as aerodynamic crosscoupling. However, the increase in rotor stability should greatly improve rotating machinery performance in the presence of such forces as well. R.C.T.

N80-29731*# Virginia Univ., Charlottesville. Dept. of Mechanical and Aerospace Engineering.
STABILIZATION OF AERODYNAMICALLY EXCITED TURBOMACHINERY WITH HYDRODYNAMIC JOURNAL BEARINGS AND SUPPORTS
Lloyd E. Barrett and Edgar J. Gunter *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 429-452 refs (For primary document see N80-29706 20-37)
(Grant NsG-3105; Contracts DAAG29-77-C-0009; EF-76-S-01-2479)
Avail: NTIS HC A20/MF A01 CSCL 13I

A method of analyzing the first mode stability and unbalance response of multimass flexible rotors is presented whereby the multimass system is modeled as an equivalent single mass modal model including the effects of rotor flexibility, general linearized hydrodynamic journal bearings, squeeze film bearing supports and rotor aerodynamic cross coupling. Expressions for optimum bearing and support damping are presented for both stability and unbalance response. The method is intended to be used as a preliminary design tool to quickly ascertain the effects of bearing and support changes on rotor-bearing system performance. R.C.T.

N80-29732*# Mechanical Technology, Inc., Latham, N. Y.
USE OF ELASTOMERIC ELEMENTS IN CONTROL OF ROTOR INSTABILITY
Anthony J. Smalley *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 453-465 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13I

The dynamic characteristics of elastomeric supports are discussed. Stiffness and damping characteristics for elastomers of various geometries including O-rings, buttons loaded in compression, and rectangular elements loaded in shear are presented. The effects of frequency, temperature, and amplitude are illustrated, as well as the effects of material and geometry. Empirical design methods are illustrated, and several examples are presented where elastomers have successfully controlled both synchronous and nonsynchronous vibrations. R.C.T.

N80-29733*# Virginia Univ., Charlottesville.
FEASIBILITY OF ACTIVE FEEDBACK CONTROL OF ROTORDYNAMIC INSTABILITY
James W. Moore, David W. Lewis, and John Heinzman *In* NASA. Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 467-476 (For primary document see N80-29706 20-37)
(Contract DE-AC01-79ET-13151)
Avail: NTIS HC A20/MF A01 CSCL 13I

Some of the considerations involved in the use of feedback control as a means of eliminating or alleviating rotordynamic instability are discussed. A simple model of a mass on a flexible shaft is used to illustrate the application of feedback control concepts. R.C.T.

N80-31795*# Eaton Corp., Southfield, Mich. Engineering and Research Center.
SMALL PASSENGER CAR TRANSMISSION TEST: FORD C4 TRANSMISSION Final Report
M. P. Bujold Jun. 1980 383 p
(Contracts DEN3-124; EC-77-A-31-1044)
(NASA-CR-159881; ERC-LIB-8060; DOE/NASA/0124-2) Avail: NTIS HC A17/MF A01 CSCL 13I

A 1979 Ford C4 automatic transmission was tested per a passenger car automatic transmission test code (SAE J651b) which required drive performance, coast performance, and no load test conditions. Under these test conditions, the transmission attained maximum efficiencies in the mid-eighty percent range for both drive performance tests and coast performance tests. The major results of this test (torque, speed, and efficiency curves) are presented. Graphs map the complete performance characteristics for the Ford C4 transmission. A.R.H.

N80-31796*# Eaton Corp., Southfield, Mich. Engineering and Research Center.
SMALL PASSENGER CAR TRANSMISSION TEST; CHEVROLET LUV TRANSMISSION Final Report
M. P. Bujold Jun. 1980 428 p
(Contract DEN3-124; EC-77-A-31-1044)
(NASA-CR-159882; ERC-LIB-80121; DOE/NASA/0124-3)
Avail: NTIS HC A19/MF A01 CSCL 13I

A 1978 Chevrolet LUV manual transmission tested per the applicable portions of a passenger car automatic transmission test code (SAE J65lb) which required drive performance, coast performance, and no load test conditions. Under these test conditions, the transmission attained maximum efficiencies in the upper ninety percent range for both drive performance tests and coast performance tests. The major results of this test (torque, speed, and efficiency curves) are presented. Graphs map the complete performance characteristics for the Chevrolet LUV transmission. A.R.H.

N80-32718*# Mechanical Technology, Inc., Latham, N. Y.
DEVELOPMENT OF PROCEDURES FOR CALCULATING STIFFNESS AND DAMPING OF ELASTOMERS IN ENGINEERING APPLICATIONS, PART 7
A. Rieger and E. Zorzi Sep. 1980 85 p refs
(Contract NAS3-21623)
(NASA-CR-165138; Rept-80TR63) Avail: NTIS HC A05/MF A01 CSCL 13I

An elastomer shear damper was designed, tested, and compared with the performance of the T 55 power turbine supported on the production engine roller bearing support. The Viton 70 shear damper was designed so that the elastomer damper could be interchanged with the production T 55 power turbine roller bearing support. The results show that the elastomer sheer dampener permitted stable operation of the power turbine to the maximum operating speed of 16,000 rpm. Author

N80-32719*# Chrysler Corp., Detroit, Mich.
UPGRADED AUTOMOTIVE GAS TURBINE ENGINE DESIGN AND DEVELOPMENT PROGRAM, VOLUME 2 Final Report
C. E. Wagner, ed. and R. C. Pampreen, ed. Jun. 1979 348 p

refs Sponsored by NASA
(Contracts EY-76-C-02-2749; EC-77-A-31-1040)
(NASA-CR-159671; DOE/NASA/2749-79/2-Vol-2;
COO-2749-43-Vol-2) Avail: NTIS HC A15/MF A01 CSCL
13I

Results are presented for the design and development of an upgraded engine. The design incorporated technology advancements which resulted from development testing on the Baseline Engine. The final engine performance with all retro-fitted components from the development program showed a value of 91 HP at design speed in contrast to the design value of 104 HP. The design speed SFC was 0.53 versus the goal value of 0.44. The miss in power was primarily due to missing the efficiency targets of small size turbomachinery. Most of the SFC deficit was attributed to missed goals in the heat recovery system relative to regenerator effectiveness and expected values of heat loss. Vehicular fuel consumption, as measured on a chassis dynamometer, for a vehicle inertia weight of 3500 lbs., was 15 MPG for combined urban and highway driving cycles. The baseline engine achieved 8 MPG with a 4500 lb. vehicle. Even though the goal of 18.3 MPG was not achieved with the upgraded engine, there was an improvement in fuel economy of 46% over the baseline engine, for comparable vehicle inertia weight.
Author

N80-32720*# Rochester Inst. of Tech., N. Y.
DEVELOPMENT OF FLEXIBLE ROTOR BALANCING CRITERIA Final Report
Wayne W. Walter and Neville F. Rieger Mar. 1979 115 p refs
(Grant NsG-3072)
(NASA-CR-159506) Avail: NTIS HC A06/MF A01 CSCL 13I

Several studies in which analytical procedures were used to obtain balancing criteria for flexible rotors are described. General response data for a uniform rotor in damped flexible supports were first obtained for plain cylindrical bearings, tilting pad bearings, axial groove bearings, and partial arc bearings. These data formed the basis for the flexible rotor balance criteria presented. A procedure by which a practical rotor in bearings could be reduced to an equivalent uniform rotor was developed and tested. It was found that the equivalent rotor response always exceeded to practical rotor response by more than sixty percent for the cases tested. The equivalent rotor procedure was then tested against six practical rotor configurations for which data was available. It was found that the equivalent rotor method offered a procedure by which balance criteria could be selected for practical flexible rotors, using the charts given for the uniform rotor.
A.R.H.

A80-14739 * # **Phase change in liquid face seals. II - Isothermal and adiabatic bounds with real fluids.** W. F. Hughes and N. H. Chao (Carnegie-Mellon University, Pittsburgh, Pa.). *American Society of Mechanical Engineers and American Society of Lubrication Engineers, Lubrication Conference, Dayton, Ohio, Oct. 16-18, 1979, ASME Paper 79-Lub-4.* 8 p. Members, $1.50; nonmembers, $3.00. Grant No. NsG-3023.

Analytical studies of phase change effects in parallel and tapered liquid face seals are presented. An isothermal and adiabatic model of low Reynolds number flow are considered by numerical integration of the descriptive equations for a real fluid, and its thermodynamic properties are calculated for each step, using a computer program for the steam tables or fluid thermodynamic properties. It was shown that for low leakage rate the isothermal model is more accurate and for high leakage rates the adiabatic model is more accurate; that both models yield the same conclusions regarding stability; and that the transient of collapse is described by the adiabatic model which predicts a catastrophic collapse and then either failure or explosive return to a larger film thickness value. Finally, it is shown that converging seals may become unstable and the mass leakage rate is reduced significantly below the all liquid value when boiling occurs.
A.T.

A80-14760 * # **Load support system analysis high speed input pinion configuration.** S. S. Gassel and J. Pirvics (SKF Industries, Inc., King of Prussia, Pa.). *American Society of Mechanical Engineers and American Society of Lubrication Engineers, Lubrication Conference, Dayton, Ohio, Oct. 16-18, 1979, ASME Paper 79-Lub-34.* 10 p. 15 refs. Members $1.50; nonmembers, $3.00. Contract No. NAS3-20839.

An analysis and a series of computerized calculations were carried out to explore competing prototype design concepts of a shaft and two taper-roller bearings systems to support the high-speed input pinion of an advanced commercial helicopter transmission. The results were used to evaluate designs both for a straddle arrangement where the pinion gear is located between the bearings and for a cantilever arrangement where the pinion is outboard of the two bearings. Effects of varying parameters including applied gear load, preload, wall thickness, interference fits, bearing spacing and pinion gear location on system rigidity, load distribution and bearing rating life were assessed. A comparison of the bearing load distributions for these designs demonstrated that the straddle more equally distributes both radial and axial loads. The performance of these designs over a range of shaft rotational speeds, with lubrication and friction effects included, is also discussed.
S.D.

A80-14761 * # **High speed cylindrical rolling element bearing analysis 'CYBEAN' - Analytic formulation.** R. J. Kleckner, J. Pirvics (SKF Industries, Inc., King of Prussia, Pa.), and V. Castelli (Xerox Corp., El Segundo, Calif.). *American Society of Mechanical Engineers and American Society of Lubrication Engineers, Lubrication Conference, Dayton, Ohio, Oct. 15-18, 1979, ASME Paper 79-Lub-35.* 9 p. 24 refs. Members, $1.50; nonmembers, $3.00. Contract No. NAS3-20068.

This paper documents the analytic foundation and software architecture for the computerized mathematical simulation of high speed cylindrical rolling element bearing behavior. The software, CYBEAN (CYlindrical BEaring ANalysis), considers a flexible, variable geometry outer ring, EHD films, roller centrifugal and quasidynamic loads, roller tilt and skew, mounting fits, cage and flange interactions. The representation includes both steady state and time transient simulation of thermal interactions internal to and coupled with the surroundings of the bearing. A sample problem illustrating program use is presented.
(Author)

A80-35574 * # **Advanced Gas Turbine Powertrain System Development Project.** H. E. Helms (General Motors Corp., Detroit Diesel Allison Div., Detroit, Mich.). *U.S. Department of Energy and NASA, International Automotive Propulsion Systems Symposium, 5th, Dearborn, Mich., Apr. 14-18, 1980, Paper.* 27 p. Contract No. DEN3-168.

A progress report on the Advanced Gas Turbine Powertrain System Development Project being performed under contract from NASA Lewis is presented. The goals and objectives of the project are described noting that funds from the DOE, Office of Transportation Programs are used to sponsor the project. Among the demonstration objectives are attaining a fuel economy of 42.5 miles per gallon in a 1985 Pontiac Phoenix, multifuel capability, and emission levels within the federal standards. Design objectives examined include competitive reliability and life as well as competitive initial and life cycle costs. Finally, it is stressed that high risk and key elements in this advanced powertrain project are the development of ceramic turbine engine components and the aerodynamic development of small size turbine components.
M.E.P.

38 QUALITY ASSURANCE AND RELIABILITY

Includes product sampling procedures and techniques, and quality control.

N80-15422*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC POWER SYSTEM RELIABILITY CONSIDERATIONS
Vincent R Lalli 1980 9 p refs Presented at the Ann. Reliability and Maintainability Symp., San Francisco, 22-24 Jan. 1980
(Contract DE-AB29-76EI-20370)
(NASA-TM-79291, DOE/NASA/20370-79/19; E-235) Avail NTIS HC A02/MF A01 CSCL 14D

An example of how modern engineering and safety techniques can be used to assure the reliable and safe operation of photovoltaic power systems is presented. This particular application is for a solar cell power system demonstration project designed to provide electric power requirements for remote villages. The techniques utilized involve a definition of the power system natural and operating environment, use of design criteria and analysis techniques, an awareness of potential problems via the inherent reliability and FMEA methods, and use of fail-safe and planned spare parts engineering philosophy. J.M.S

N80-22714*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SIMULATION OF TRANSDUCER-COUPLANT EFFECTS ON BROADBAND ULTRASONIC SIGNALS
Alex Vary 1980 36 p refs Presented at Spring Meeting of the Am. Soc. of Nondestructive Testing, Philadelphia, 24-27 Mar. 1980
(NASA-TM-81489; E-427) Avail: NTIS HC A03/MF A01 CSCL 14D

The increasing use of broadband, pulse-echo ultrasonics in nondestructive evaluation of flaws and material properties has generated a need for improved understanding of the way signals are modified by coupled and bonded thin-layer interfaces associated with transducers. This understanding is most important when using frequency spectrum analyses for characterizing material properties. In this type of application, signals emanating from material specimens can be strongly influenced by couplant and bond-layers in the acoustic path. Computer synthesized waveforms were used to simulate a range of interface conditions encountered in ultrasonic transducer systems operating in the 20 to 80 MHz regime. The adverse effects of thin-layer multiple reflections associated with various acoustic impedance conditions are demonstrated. The information presented is relevant to ultrasonic transducer design, specimen preparation, and couplant selection. Author

N80-24634*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONCEPTS AND TECHNIQUES FOR ULTRASONIC EVALUATION OF MATERIAL MECHANICAL PROPERTIES
Alex Vary 1980 21 p refs To be presented at the Conf. on Mech. of Nondestructive Testing, Blacksburg, Va., 10-12 Sep. 1980
(NASA-TM-81523; E-467) Avail: NTIS HC A02/MF A01 CSCL 14D

Ultrasonic methods that can be used for material strength are reviewed. Emergency technology involving advanced ultrasonic techniques and associated measurements is described. It is shown that ultrasonic NDE is particularly useful in this area because it involves mechanical elastic waves that are strongly modulated by morphological factors that govern mechanical strength and also dynamic failure modes. These aspects of ultrasonic NDE are described in conjunction with advanced approaches and theoretical concepts for signal acquisition and analysis for materials characterization. It is emphasized that the technology is in its infancy and that much effort is still required before the techniques and concepts can be transferred from laboratory to field conditions. A.R.H.

N80-26682*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
QUANTITATIVE ULTRASONIC EVALUATION OF ENGINEERING PROPERTIES IN METALS, COMPOSITES AND CERAMICS
Alex Vary 1980 18 p refs Presented at First Seminar on Advanced Ultrasonic Tech., Longueuil, Quebec, 9-10 Jun. 1980; sponsored by National Research Council of Canada
(NASA-TM-81530; E-482) Avail: NTIS HC A02/MF A01 CSCL 14D

Ultrasonic technology from the perspective of nondestructive evaluation approaches to material strength prediction and property verification is reviewed. Emergent advanced technology involving quantitative ultrasonic techniques for materials characterization is described. Ultrasonic methods are particularly useful in this area because they involve mechanical elastic waves that are strongly modulated by the same morphological factors that govern mechanical strength and dynamic failure processes. It is emphasized that the technology is in its infancy and that much effort is still required before all the available techniques can be transferred from laboratory to industrial environments. E.D.K.

A80-51575 * # **Concepts and techniques for ultrasonic evaluation of material mechanical properties.** A. Vary (NASA, Lewis Research Center, Cleveland, Ohio). *Virginia Polytechnic Institute and State University, Conference on Mechanics of Nondestructive Testing, Virginia Polytechnic Institute and State University, Blacksburg, Va., Sept. 10-12, 1980, Paper.* 19 p. 37 refs.

The ultrasonic nondestructive evaluation techniques discussed in the present paper indicate potentials for material characterization and property prediction. Stress wave interaction and material transfer function concepts are examined as a basis for explaining correlations between material mechanical behavior and ultrasonically measured quantities. It is observed that the effect and criticality of any discrete flaw, such as crack, inclusion, or any other stress raiser, is definable only in terms of its material microstructural environment. This underscores the importance of ultrasonic techniques capable of characterizing the stress wave energy transfer properties of a material. V.P.

A80-39641 * # **Quantitative ultrasonic evaluation of engineering properties in metals, composites, and ceramics.** A. Vary (NASA, Lewis Research Center, Cleveland, Ohio). *National Research Council of Canada, Seminar on Advanced Ultrasonic Technology, 1st, Longueuil, Quebec, Canada, June 9, 10, 1980, Paper.* 16 p. 84 refs.

Ultrasonic techniques that have demonstrated potential for material characterization are reviewed. These techniques rely on physical acoustic properties of materials and the interaction of elastic stress waves with morphological factors in the ultrasonic regime. The speed of wave propagation and energy loss by interaction with material microstructure and geometrical factors underlie ultrasonic determination of material properties. Two categories of ultrasonic measurements are discussed: those related to material strengths (e.g., elastic moduli, tensile strength, and fracture toughness) and those related to morphology and material conditions that govern strength and performance (e.g., microstructure, void content, residual stress, fatigue damage). It is shown that large-scale industrial application of ultrasonic NDE will depend on advancement in such areas as theory development, instrumentation, system automation, standardization, and coordination with design. V.L.

N80-13503 Syracuse Univ., N. Y.
MODELLING OF CRACK TIP DEFORMATION WITH FINITE ELEMENT METHOD AND ITS APLICATIONS Ph.D. Thesis
Chuang-Yeh Yang 1979 125 p
Avail: Univ. Microfilms Order No. 7925610

A finite element computer program using the initial stress approach of elastic-plastic analysis was developed. Crack closure stresses were calculated for three different models. It was concluded that (1) the closure stress is highest in the strip necking model, lowest in the plane strain model, and intermediate in the plane stress model, and (2) the crack closure stress decreases if the separation occurs before the stress reaches the maximum value. Nonpropagating fatigue cracks in the two phase martensitic-ferritic steels were also investigated. Unzipping increments were calculated for different crack lengths. At a prescribed stress intensity level, the shorter the crack length, the greater the unzipping increment is. This means that the shorter crack will grow faster than the longer one if both are subjected to the same K-level. Dissert. Abstr.

39 STRUCTURAL MECHANICS

Includes structural element design and weight analysis, fatigue, and thermal stress

For applications see *05 Aircraft Design, Testing and Performance* and *18 Spacecraft Design, Testing and Performance*.

N80-13513*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARISON TESTS AND EXPERIMENTAL COMPLIANCE CALIBRATION OF THE PROPOSED STANDARD ROUND COMPACT PLANE STRAIN FRACTURE TOUGHNESS SPECIMEN

D. M. Fisher and R. J. Buzzard Nov. 1979 21 p refs

(NASA-TM-81379; E-284) Avail: NTIS HC A02/MF A01 CSCL 20K

Standard round specimen fracture test results compared satisfactorily with results from standard rectangular compact specimens machined from the same material. The location of the loading pin holes was found to provide adequate strength in the load bearing region for plane strain fracture toughness testing. Excellent agreement was found between the stress intensity coefficient values obtained from compliance measurements and the analytic solution proposed for inclusion in the standard test method. Load displacement measurements were made using long armed displacement gages and hollow loading cylinders. Gage points registered on the loading hole surfaces through small holes in the walls of the loading cylinders. Author

N80-15428*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A RELATION BETWEEN SEMIEMPIRICAL FRACTURE ANALYSES AND R-CURVES

Thomas W. Orange Jan. 1980 45 p refs

(NASA-TP-1600; E-9963) Avail: NTIS HC A03/MF A01 CSCL 20K

The relations between several semiempirical fracture analyses (SEFA) and the R-curve concept of fracture mechanics are examined and the conditions for equivalence between a SEFA and an R-curve are derived. A hypothetical material is employed to study the relation analytically. Equivalent R-curves are developed for several real materials using data from the literature. For each SEFA there is an equivalent R-curve whose magnitude and shape are determined by the SEFA formulation and its empirical parameters. If the R-curve is indeed unique, then the various empirical parameters cannot be constant, and vice versa. However, for one SEFA the differences are small enough that they may be within the range of normal data scatter for real materials. Author

N80-22734*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NONLINEAR, THREE-DIMENSIONAL FINITE-ELEMENT ANALYSIS OF AIR-COOLED GAS TURBINE BLADES

Albert Kaufman and Raymond E. Gaugler Apr. 1980 22 p refs

(NASA-TP-1669; E-074) Avail: NTIS HC A02/MF A01 CSCL 21E

Cyclic stress-strain states in cooled turbine blades were calculated for a simulated mission of an advanced-technology commercial aircraft engine. The MARC, nonlinear, finite-element computer program was used for the analysis of impingement-cooled airfoils, with and without leading-edge film cooling. Creep was the predominant damage mode (ignoring hot corrosion), particularly artund film-cooling holes. Radially angled holes exhibited less creep than holes with axes normal to the surface. Beam-theory analyses of all-impingement-cooled airfoils gave fair agreement with MARC results for initial creep. Author

N80-23678*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STATUS OF NASA FULL-SCALE ENGINE AEROELASTICITY RESEARCH

Joseph F. Lubomski 1980 21 p refs Presented at the 21st Struct., Structural Dyn., and Mater. Conf., Seattle, 12-14 May 1980, sponsored by AIAA, ASME, ASCE and AHS

(NASA-TM-81500; E-437) Avail: NTIS HC A02/MF A01 CSCL 20K

Data relevant to several types of aeroelastic instabilities were obtained using several types of turbojet and turbofan engines. In particular, data relative to separated flow (stall) flutter, choke flutter, and system mode instabilities are presented. The unique characteristics of these instabilities are discussed, and a number of correlations are presented that help identify the nature of the phenomena. R.E.S.

N80-23684*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRACTICAL IMPLEMENTATION OF THE DOUBLE LINEAR DAMAGE RULE AND DAMAGE CURVE APPROACH FOR TREATING CUMULATIVE FATIGUE DAMAGE

S. S. Manson (Case Western Reserve Univ.) and G. R. Halford Apr. 1980 50 p refs

(NASA-TM-81517; E-387) Avail: NTIS HC A03/MF A01 CSCL 20K

Simple procedures are presented for treating cumulative fatigue damage under complex loading history using either the damage curve concept or the double linear damage rule. A single equation is provided for use with the damage curve approach; each loading event providing a fraction of damage until failure is presumed to occur when the damage sum becomes unity. For the double linear damage rule, analytical expressions are provided for determining the two phases of life. The procedure involves two steps, each similar to the conventional application of the commonly used linear damage rule. When the sum of cycle ratios based on phase 1 lives reaches unity, phase 1 is presumed complete, and further loadings are summed as cycle ratios on phase 2 lives. When the phase 2 sum reaches unity, failure is presumed to occur. No other physical properties or material constants than those normally used in a conventional linear damage rule analysis are required for application of either of the two cumulative damage methods described. Illustrations and comparisons of both methods are discussed. Author

N80-27719*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARISON OF ELASTIC AND ELASTIC-PLASTIC STRUCTURAL ANALYSES FOR COOLED TURBINE BLADE AIRFOILS

Albert Kaufman Jul. 1980 15 p refs

(NASA-TP-1679; E-241) Avail: NTIS HC A02/MF A01 CSCL 20K

Elastic plastic stress strain states in cooled turbine blade airfoils were calculated by three methods for the initial takeoff transient of an advanced technology aircraft engine. The three analytical methods compared were a three dimensional elastic plastic, finite element analysis, a three dimensional, elastic, finite element analysis, and a one dimensional, elastic plastic, beam theory analysis. Structural analyses were performed for eight cases involving different combinations of mechanical and thermal loading on impingement cooled airfoils with and without leading edge film cooling holes. The von Mises effective total strains at maximum takeoff computed from the elastic and elastic plastic finite element analyses agreed with 9 percent for rotating airfoils and 28 percent for stationary airfoils with the elastic results on the conservative side. Author

N80-32753*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE METHOD OF LINES IN THREE DIMENSIONAL FRACTURE MECHANICS

John Gyekenyesi and Laszlo Berke Washington 1980 19 p refs Presented at the Intern. Symp. on Absorbed Specific Energy and/or Strain Energy Density Criterion, Budapest, 17-19 Sep.

1980, sponsored by Lehigh Univ and the Hungarian Acad of Sci
(NASA-TM-81593, E-576) Avail NTIS HC A02/MF A01 CSCL 20K

A review of recent developments in the calculation of design parameters for fracture mechanics by the method of lines (MOL) is presented. Three dimensional elastic and elasto-plastic formulations are examined and results from previous and current research activities are reported. The application of MOL to the appropriate partial differential equations of equilibrium leads to coupled sets of simultaneous ordinary differential equations. Solutions of these equations are obtained by the Peano-Baker and by the recurrance relations methods. The advantages and limitations of both solution methods from the computational standpoint are summarized. R.K.G.

A80-10832 * **Simple spline-function equations for fracture mechanics calculations.** T. W. Orange (NASA, Lewis Research Center, Cleveland, Ohio). *International Journal of Fracture*, vol. 15, Oct. 1979, p. R161-R163. 8 refs.

The paper presents simple spline-function equations for fracture mechanics calculations. A spline function is a sequence of piecewise polynomials of degree n greater than 1 whose coefficients are such that the function and its first n-1 derivatives are continuous. Second-degree spline equations are presented for the compact, three point bend, and crack-line wedge-loaded specimens. Some expressions can be used directly, so that for a cyclic crack propagation test using a compact specimen, the equation given allows the cracklength to be calculated from the slope of the load-displacement curve. For an R-curve test, equations allow the crack length and stress intensity factor to be calculated from the displacement and the displacement ratio. A.T.

A80-20149 * **Buckling of rotating beams.** W. F. White, Jr. (U.S. Army, Structures Laboratory, Hampton, Va.), R. G. Kvaternik (NASA, Langley Research Center, Hampton, Va.), and K. R. V. Kaza (NASA, Lewis Research Center, Cleveland; Toledo, University, Toledo, Ohio). *International Journal of Mechanical Sciences*, vol. 21, no. 12, 1979, p. 739-745. 12 refs.

The stability of a beam subjected to compressive centrifugal forces arising from steady rotation about an axis which does not pass through the clamped end of the beam is analyzed to determine the critical rotational speeds for buckling in the inplane and out-of-plane directions. The differential equations of motion are solved numerically using an integrating matrix method in combination with an eigenanalysis to determine the eigenvalues from which stability is assessed. The results clarify several differences which have been identified in the literature relating to the proper behavior of the critical rotational speed for buckling as the radius of rotation of the clamped end of the beam is reduced. (Author)

A80-27958 * # **Strainrange partitioning life predictions of the long time Metal Properties Council creep-fatigue tests.** J. F. Saltsman and G. R. Halford (NASA, Lewis Research Center, Cleveland, Ohio). In: Methods for predicting material life in fatigue; Proceedings of the Winter Annual Meeting, New York, N.Y., December 2-7, 1979. (A80-27951 10-39) New York, American Society of Mechanical Engineers, 1979, p. 101-132. 23 refs.

The method of Strainrange Partitioning is used to predict the cyclic lives of the Metal Properties Council's long time creep-fatigue interspersion tests of several steel alloys. Comparisons are made with predictions based upon the Time- and Cycle-Fraction approach. The method of Strainrange Partitioning is shown to give consistently more accurate predictions of cyclic life than is given by the Time- and Cycle-Fraction approach. (Author)

A80-32067 * # **Prediction of fiber composite mechanical behavior made simple.** C. C. Chamis (NASA, Lewis Research Center, Materials and Structures Div., Cleveland, Ohio). In: Rising to the challenge of the '80s; Annual Conference and Exhibit, 35th, New Orleans, La., February 4-8, 1980, Preprints. (A80-32058 12-24) New York, Society of the Plastics Industry, Inc., 1980, p. 12-A 1 to 12-A 10.

A convenient procedure is described for the determination of the mechanical behavior (elastic properties and failure stresses of angleplied fiber composite laminates using a pocket calculator. The procedure consists of simple equations and appropriate graphs of (plus or minus theta) ply combinations. The procedure can handle all types of fiber composites including hybrids. The versatility and generality of the procedure is illustrated using several step-by-step numerical examples. (Author)

A80-35906 * # **Status of NASA full-scale engine aeroelasticity research.** J. F. Lubomski (NASA, Lewis Research Center, Cleveland, Ohio). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Conference sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, Inc., 1980. 18 p. 14 refs.

The paper presents data relevant to several types of aeroelastic instabilities which have been obtained using several types of turbojet and turbofan engines. Special attention is given to data relative to separated flow (stall) flutter, choke flutter, and system mode instabilities. The discussion covers the characteristics of these instabilities, and a number of correlations are presented that help identify the nature of the phenomena. M.E.P.

A80-38142 * # **A quarter-century of progress in the development of correlation and extrapolation methods for creep rupture data.** S. S. Manson (Case Western Reserve University, Cleveland, Ohio) and C. R. Ensign (NASA, Lewis Research Center, Cleveland, Ohio). *ASME, Transactions, Journal of Engineering Materials and Technology*, vol. 101, Oct. 1979, p. 317-325. 32 refs.

Developments in the analysis of creep-rupture data are reviewed with particular reference to time temperature relations for the correlation and extrapolation of creep and stress rupture data, the minimum commitment method, and successive regression methods. Some contributions to the development of time-temperature parameters are noted. V.P.

A80-45364 * **Vibration and buckling of rectangular plates under in-plane hydrostatic loading.** R. E. Kielb (NASA, Lewis Research Center, Cleveland, Ohio) and L. S. Han (Ohio State University, Columbus, Ohio). *Journal of Sound and Vibration*, vol. 70, June 22, 1980, p. 543-555. 15 refs.

Numerical solutions are presented for the fundamental natural frequency and mode shape of a rectangular plate loaded by in-plane hydrostatic forces for a wide variety of aspect ratios, boundary conditions, and load magnitudes. All six possible combinations of simply supported and clamped edges are considered. The limiting conditions of unloaded vibration and buckling are discussed in detail, with emphasis on the preferred mode shape. Design curves and approximate formulae are presented which provide a simple means of determining the fundamental frequency parameter. (Author)

A80-46032 * **Compliance and stress intensity coefficients for short bar specimens with chevron notches.** D. Munz (NASA, Lewis Research Center, Cleveland, Ohio; Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Cologne, West Germany), R. T. Bubsey, and J. E. Srawley (NASA, Lewis Research Center, Cleveland, Ohio). *International Journal of Fracture*, vol. 16, Aug. 1980, p. 359-374. 15 refs. Contract No. EC-77-A-31-1040.

For the determination of fracture toughness especially with brittle materials, a short bar specimen with rectangular cross section and chevron notch can be used. As the crack propagates from the tip of the triangular notch, the load increases to a maximum then decreases. To obtain the relation between the fracture toughness and maximum load, calculations of Srawley and Gross for specimens with a straight-through crack were applied to the specimens with chevron notches. For the specimens with a straight-through crack, an analytical expression was obtained. This expression was used for the calculation of the fracture toughness versus maximum load relation under the assumption that the change of the compliance with crack length for the specimen with a chevron notch is the same as for a specimen with a straight-through crack. (Author)

N80-10515*# Pratt and Whitney Aircraft Group, East Hartford, Conn Commercial Products Div
EFFECT OF TIME DEPENDENT FLIGHT LOADS ON JT9D-7 PERFORMANCE DETERIORATION
A Jay and B L Lewis 21 Aug 1979 73 p refs
(Contract NAS3-20632)
(NASA-CR-159681; PWA-5512-45) Avail NTIS
HC A04/MF A01 CSCL 01C

The results of a modal transient analysis of the engine/aircraft system are presented The response of the JT9D to analytically simulated vertical gusts and landings was predicted using a NASTRAN finite element mathematical model of the JT9D/747 propulsion system The NASTRAN finite element model of the propulsion system included engine structural models of the fan, low/high pressure compressors, diffuser/turbine cases, and high/low pressure rotors, as well as nacelle models of the inlet cowl, tailcone, and wing pylon The analysis conducted predicts that an insignificant level of JT9D-7 performance deterioration would occur due to a typical vertical gust encounter or a typical revenue service landing Analysis of a high sink rate landing with a heavy fuel load indicates the possibility of local wear, however, the lack of an accurate dynamic rotor/seal interference model precludes an accurate quantitative evaluation of performance change for this once-per-airframe-life event. J.M.S.

N80-22733*# Mechanical Technology, Inc., Latham, N. Y.
DEVELOPMENT OF PROCEDURES FOR CALCULATING STIFFNESS AND DAMPING OF ELASTOMERS IN ENGINEERING APPLICATIONS, PART 6
A Rieger, G Burgess, and E Zorzi Apr 1980 157 p refs
(Contract NAS3-18546)
(NASA-CR-159838; MTI-80TR29) Avail: NTIS
HC A08/MF A01 CSCL 20K

An elastomer damper was designed, tested, and compared with the performance of a hydraulic damper for a power transmission shaft The six button Viton-70 damper was designed so that the elastomer damper or the hydraulic damper could be activated without upsetting the imbalance condition of the assembly. This permitted a direct comparison of damper effectiveness. The elastomer damper consistently performed better than the hydraulic mount and permitted stable operation of the power transmission shaft to speeds higher than obtained with the squeeze film damper. Tests were performed on shear specimens of Viton-79, Buna-N, EPDM, and Neoprene to determine performance limitations imposed by strain, temperature, and frequency. Frequencies of between 110 Hz and 1100 Hz were surveyed with imposed strains between 0.0005 and 0.08 at temperatures of 32 C, 66 C, and 80 C. A set of design curves was generated in a unified format for each of the elastomer materials. E.D.K.

N80-27720*# Massachusetts Inst. of Tech., Cambridge. Aeroelastic and Structures Research Lab
INSTRUCTIONS FOR THE USE OF THE CIVM-JET 4C FINITE-STRAIN COMPUTER CODE TO CALCULATE THE TRANSIENT STRUCTURAL RESPONSES OF PARTIAL AND/OR COMPLETE ARBITRARILY-CURVED RINGS SUBJECTED TO FRAGMENT IMPACT
Jose J. A. Rodal, Susan E. French, Emmett A. Witmer, and Thomas R. Stagliano Dec, 1979 38 p refs
(Grant NGR-22-009-339)
(NASA-CR-159873; ASTL-MR-154-1) Avail: NTIS
HC A03/MF A01

The CIVM-JET 4C computer program for the 'finite strain' analysis of 2 d transient structural responses of complete or partial rings and beams subjected to fragment impact stored on tape as a series of individual files Which subroutines are found in these files are described in detail. All references to the CIVM-JET 4C program are made assuming that the user has a copy of NASA CR-134907 (ASRL TR 154-9) which serves as a user's guide to (1) the CIVM-JET 4B computer code and (2) the CIVM-JET 4C computer code 'with the use of the modified input instructions' attached hereto. L.F.M

N80-29782*# Massachusetts Inst. of Tech., Cambridge.
FINITE-STRAIN LARGE-DEFLECTION ELASTIC-VISCOPLASTIC FINITE-ELEMENT TRANSIENT RESPONSE ANALYSIS OF STRUCTURES
Jose J. A. Rodal and Emmett A. Witmer Jul. 1979 567 p refs
(Grant NGR-22-009-339)
(NASA-CR-159874; ASRL-TR-154-15) Avail: NTIS
HC A24/MF A01 CSCL 20K

A method of analysis for thin structures that incorporates finite strain, elastic-plastic, strain hardening, time dependent material behavior implemented with respect to a fixed configuration and is consistently valid for finite strains and finite rotations is developed. The theory is formulated systematically in a body fixed system of convected coordinates with materially embedded vectors that deform in common with continuum. Tensors are considered as linear vector functions and use is made of the dyadic representation. The kinematics of a deformable continuum is treated in detail, carefully defining precisely all quantities necessary for the analysis. The finite strain theory developed gives much better predictions and agreement with experiment than does the traditional small strain theory, and at practically no additional cost. This represents a very significant advance in the capability for the reliable prediction of nonlinear transient structural resposes, including the reliable prediction of strains large enough to produce ductile metal rupture. E.D.K.

42 GEOSCIENCES (GENERAL)

N80-18690* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INTRA-OCULAR PRESSURE NORMALIZATION TECHNIQUE AND EQUIPMENT Patent
William J. McGannon, inventor (to NASA) Issued 22 Jan. 1980 5 p Filed 31 Aug. 1977 Supersedes N77-30727 (15 - 21, p 2839)
(NASA-Case-LEW-12723-1; US-Patent-4,184,491; US-Patent-Appl-SN-829317; US-Patent-Class-128-276; US-Patent-Class-128-760) Avail: US Patent and Trademark Office CSCL 06B

A method and apparatus for safely reducing abnormally high intraocular pressure in an eye during a predetermined time interval is presented. This allows maintenance of normal intraocular pressure during glaucoma surgery. According to the invention, a pressure regulator of the spring biased diaphragm type is provided with additional bias by a column of liquid. The height of the column of liquid is selected such that the pressure at a hypodermic needle connected to the output of the pressure regulator is equal to the measured pressure of the eye. The hypodermic needle can then be safely inserted into the anterior chamber of the eye. Liquid is then bled out of the column to reduce the bias on the diaphragm of the pressure regulator and, consequently, the output pressure of the regulator. This lowering pressure of the regulator also occurs in the eye by means of a small second bleed path provided between the pressure regulator and the hypodermic needle. Alternately, a second hypodermic needle may be inserted into the eye to provide a controlled leak off path for excessive pressure and clouded fluid from the anterior chamber.

Official Gazette of the U.S. Patent and Trademark Office

43 EARTH RESOURCES

Includes remote sensing of earth resources by aircraft and spacecraft, photogrammetry, and aerial photography.
For instrumentation see *35 Instrumentation and Photography*.

N80-15538*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POSSIBLE METHODS FOR DISTINGUISHING ICEBERGS FROM SHIPS BY AERIAL REMOTE SENSING
Walton L. Howes Dec. 1979 36 p refs
(NASA-TM-79310; E-266) Avail: NTIS HC A03/MF A01 CSCL 08L

The simplest methods for aerial remote sensing which are least affected by atmospheric opacities are summarized. Radar is preferred for targets off the flight path, and microwave radiometry for targets along the flight path. Radar methods are classified by ability to resolve targets. Techniques which do not require target resolution are preferred. Among these techniques, polarization methods appear most promising, specifically those which differentiate the expected relatively greater depolarization by icebergs from that by ships or which detect doubly-reversed circular polarization. R.C.T.

N80-18497*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NUMERICAL CALCULATION OF STEADY INVISCID FULL POTENTIAL COMPRESSIBLE FLOW ABOUT WIND TURBINE BLADES
Djordje S. Dulikravich 1980 11 p refs Presented at the Wind Energy Conf., Boulder, Colo., 9-11 Apr. 1980; sponsored by AIAA and Midwest Energy Research Inst.
(NASA-TM-81438; E-361; AIAA-Paper-80-0607) Avail: NTIS HC A02/MF A01 CSCL 10B

An exact nonlinear mathematical model that accounts for three-dimensional cascade effects about the inner portions of the rotor blades and compressibility effects about the tip regions of the blades was derived. An artificially time dependent version was iteratively solved by a finite volume technique involving an artificial viscosity and a three-level consecutive mesh refinement. The exact boundary conditions were applied by generating a boundary conforming periodic computation mesh. K.L.

N80-20787*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ASSESSMENT OF SATELLITE AND AIRCRAFT MULTISPECTRAL SCANNER DATA FOR STRIP-MINE MONITORING
Ernie W. Spisz and Joyce T. Dooley Washington Mar. 1980 39 p Original contains color illustrations
(NASA-TM-79268; E-187) Avail: NTIS HC A03/MF A01 CSCL 08I

The application of LANDSAT multispectral scanner data to describe the mining and reclamation changes of a hilltop surface coal mine in the rugged, mountainous area of eastern Kentucky is presented. Original single band satellite imagery, computer enhanced single band imagery, and computer classified imagery are presented for four different data sets in order to demonstrate the land cover changes that can be detected. Data obtained with an 11 band multispectral scanner on board a C-47 aircraft at an altitude of 3000 meters are also presented. Comparing the satellite data with color, infrared aerial photography, and ground survey data shows that significant changes in the disrupted area can be detected from LANDSAT band 5 satellite imagery for mines with more than 100 acres of disturbed area. However, band-ratio (bands 5/6) imagery provides greater contrast than single band imagery and can provide a qualitative level 1 classification of the land cover that may be useful for monitoring either the disturbed mining area or the revegetation progress. However, if a quantitative, accurate classification of the barren or revegetated classes is required, it is necessary to perform a detailed, four band computer classification of the data. J.M.S.

44 ENERGY PRODUCTION AND CONVERSION

Includes specific energy conversion systems, e.g., fuel cells and batteries; global sources of energy; fossil fuels; geophysical conversion; hydroelectric power; and wind power.

For related information see also *07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels,* and *85 Urban Technology and Transportation.*

N80-10594*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOME TECHNIQUES FOR REDUCING THE TOWER SHADOW OF THE DOE/NASA MOD-0 WIND TURBINE TOWER Final Report
Richard R. Burley, Joseph M. Savino, Lee H. Wagner, and James H. Diedrich Sep. 1979 129 p refs
(Contract DE-AB29-76-ET20370)
(NASA-TM-79202; DOE/NASA/20370-79/17; E-087) Avail: NTIS HC A07/MF A01 CSCL 10B

Wind speed profile measurements to measure the effect of a wind turbine tower on the wind velocity are presented. Measurements were made in the wake of scale models of the tower and in the wake of certain full scale components to determine the magnitude of the speed reduction (tower shadow). Shadow abatement techniques tested on the towers included the removal of diagonals, replacement of diagonals and horizontals with round cross section members, installation of elliptical shapes on horizontal members, installation of airfoils on vertical members, and application of surface roughness to vertical members.
A.W.H.

N80-10595*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA-LEWIS CLOSED-CYCLE MAGNETOHYDRODYNAMICS PLANT ANALYSIS
Paul F. Penko 1979 13 p refs Presented at Closed-Cycle Magnetohydrodynamics Specialists Meeting, Bozeman, Montana, 21 Jun. 1979
(Contract EF-77-A-01-2674)
(NASA-TM-79249; DOE/NASA-2674-79/7; E-159) Avail: NTIS HC A02/MF A01 CSCL 10A

A brief review of preliminary analyses of coal fired closed cycle MHD power plants is presented. The performance of three power plants with differing combustion systems were compared. The combustion systems considered were (1) a direct coal-fired combustor, (2) a coal gasifier with in-bed desulfurization and (3) a coal gasifier requiring external fuel gas cleanup. Power plant efficiencies (auxiliary power excluded) were 44.5, 43, and 41 percent for the three plants, respectively.
R.E.S.

N80-12552*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A PHOTOVOLTAIC POWER SYSTEM IN THE REMOTE AFRICAN VILLAGE OF TANGAYE, UPPER VOLTA
William J. Bifano, Anthony F. Ratajczak, and James E. Martz 1979 17 p refs Presented at UNITAR Conf. on Long-Term Energy Resources, Montreal, 26 Nov. - 7 Dec. 1979 Sponsored in part by AID
(NASA-TM-79318; E-274) Avail: NTIS HC A02/MF A01 CSCL 10B

A photovoltaic (PV) system powering a grain mill and a water pump was installed in the remote West African village of Tangaye, Upper Volta. Village characteristics as well as system design, hardware, installation and operation to date are described. The PV system cost is discussed. A baseline socio-economic study performed and a follow-up study is planned to determine the impact of the system on the villagers.
R.E.S.

N80-13623*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MODIFIED POWER LAW EQUATIONS FOR VERTICAL WIND PROFILES
D. A. Spera and T. R. Richards 1979 13 p refs Presented at the Wind Characteristics and Wind Energy Siting Conf., Portland, Oreg., 19-21 Jun. 1979 Sponsored by DOE, American Meteorological Soc., Pacific Northwest Lab.
(E(49-26)-1059)
(NASA-TM-79275; DOE/NASA/1059-79/4) Avail: NTIS HC A02/MF A01 CSCL 10A

Equations are presented for calculating power law exponents from wind speed and surface roughness data. Results are evaluated by comparison with wind profile data measured at a variety of sites.
Author

N80-13624*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LOW NO(X) HEAVY FUEL COMBUSTOR PROGRAM
Eric Lister (DOE, Germantown, Md.), Richard W. Niedzwiecki, and Lester Nichols [1979] 15 p To be presented at 25th Ann. Intern. Gas Turbine Conf., New Orleans, 9-13 Mar. 1980; sponsored by ASME
(Contract EC-77-A-31-1062)
(NASA-TM-79313; E-269; DOE/NASA/1062-79/3) Avail: NTIS HC A02/MF A01 CSCL 10B

The 'low nitrogen oxides heavy fuel combustor' program is described. Main program objectives are to generate and demonstrate the technology required to develop durable gas turbine combustors for utility and industrial applications, which are capable of sustained, environmentally acceptable operation with minimally processed petroleum residual fuels. The program will focus on 'dry' reductions of oxides of nitrogen, improved combustor durability, and satisfactory combustion of minimally processed petroleum residual fuels. Other technology advancements sought include: fuel flexibility for operation with petroleum distillates, blends of petroleum distillates and residual fuels, and synfuels (fuel oils derived from coal or shale); acceptable exhaust emissions of carbon monoxide, unburned hydrocarbons, sulfur oxides and smoke; and retrofit capability to existing engines.
R.E.S.

N80-14472* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SELF-RECONFIGURING SOLAR CELL SYSTEM Patent
Robert P. Gruber, inventor (to NASA) Issued 20 Nov. 1979 10 p filed 19 Jun. 1978 Supersedes N78-27520 (16 - 18, p 2408)
(NASA-Case-LEW-12586-1; US-Patent-4,175,249; US-Patent-Appl-SN-916655; US-Patent-Class-323-15; US-Patent-Class-307-63; US-Patent-Class-307-66; US-Patent-Class-323-19) Avail: US Patent and Trademark Office CSCL 10A

A self-reconfiguring solar cell array is disclosed wherein some of the cells are switched so that they can be either in series or in shunt within the array. This feature of series or parallel switching of cells allows the array to match the load to achieve maximum power transfer. Automatic control is used to determine the conditions for maximum power operation and to switch the array into the appropriate configuration necessary to transfer maximum power to the load.
Official Gazette of the U.S. Patent and Trademark Office

N80-14493*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATUS OF THE DOE/NASA CRITICAL GAS TURBINE RESEARCH AND TECHNOLOGY PROJECT
John S. Clark 1980 21 p refs Proposed for presentation the 25th Annual Gas Turbine Conf., New Orleans, 9-13 Mar. 1980; sponsored by the Am. Soc. of Mech. Engineers
(Contract EF-77-A-01-2593)
(NASA-TM-79307; DOE/NASA/2593-79/11; E-263) Avail: NTIS HC A02/MF A01 CSCL 10B

Activities performed in order to provide an R&T data base for utility gas turbine systems burning coal-derived fuels are described Experiments were run to determine the corrosivity effects of trace metal contaminants (and potential fuel additives) on gas turbine materials and these results were correlated in a corrosion-life prediction model. Actual fuels were burned in a burner rig hot corrosion test to verify the model. A deposition prediction model was assembled and compared with results of actual coal-derived fuel deposition tests. Thermal barrier coatings were tested to determine their potential for protecting gas turbine hardware from the corrosive contaminants. Several coatings were identified with significantly improved spallation-resistance (and, hence, corrosion resistance). A.R.H.

N80-15554*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPACE SOLAR CELLS: HIGH EFFICIENCY AND RADIATION DAMAGE

Henry W. Brandhorst, Jr. and Daniel T. Bernatowicz 1980 12 p refs Presented at 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE

(NASA-TM-81387; E-297) Avail: NTIS HC A02/MF A01 CSCL 10A

The progress and status of efforts to increase the end-of-life efficiency of solar cells for space use is assessed. High efficiency silicon solar cells, silicon solar cell radiation damage, GaAs solar cell performance and radiation damage and 30 percent devices are discussed R.E.S.

N80-15555*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPEN-CIRCUIT VOLTAGE IMPROVEMENTS IN LOW RESISTIVITY SOLAR CELLS

M. P. Godlewski, T. M. Klucher, G. A. Mazaris, and V. G. Weizer 1980 11 p refs Presented at 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE (NASA-TM-81388; E-298) Avail: NTIS HC A02/MF A01 CSCL 10A

Improvements in the open circuit voltage of 0.1 ohm-cm silicon solar cells were achieved using a multistep diffusion technique. Experimental details are given along with the results of an analysis that indicate that anomalous behavior of the electron mobility in the cell base limits attainment of higher voltages.
Author

N80-15556*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

BACK SURFACE REFLECTORS FOR SOLAR CELLS

An-Ti Chai Chai 1980 10 p refs Presented at 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE

(NASA-TM-81390; E-300) Avail: NTIS HC A02/MF A01 CSCL 10A

Sample solar cells were fabricated to study the effects of various back surface reflectors on the device performance. They are typical 50 micrometers thick, space quality, silicon solar cells except for variations of the back contact configuration. The back surfaces of the sample cells are polished to a mirror like finish, and have either conventional full contacts or grid finger contacts. Measurements and evaluation of various metallic back surface reflectors, as well as cells with total internal reflection, are presented. Results indicate that back surface reflectors formed using a grid finger back contact are more effective reflectors than cells with full back metallization and that Au, Ag, or Cu are better back surface reflector metals than Al. R.C.T.

N80-15557*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RADIATION DAMAGE IN LITHIUM-COUNTERDOPED N/P SILICON SOLAR CELLS

A. M. Hermann (Tulane Univ.), C. K. Swartz, H. W. Brandhorst, Jr., and I. Weinberg 1980 13 p refs Presented at the 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE

(NASA-TM-81391; E-301) Avail: NTIS HC A02/MF A01 CSCL 10A

Lithium counterdoped n+/p silicon solar cells were irradiated with 1 MV electrons and their post irradiation performance and low temperature annealing properties were compared to that of the 0.35 ohm cm control cells. Cells fabricated from float zone and Czochralski grown silicon were investigated. It was found that the float zone cells exhibited superior radiation resistance compared to the control cells, while no improvement was noted for the Czochralski grown cells. Room temperature and 60 C annealing studies were conducted. The annealing was found to be a combination of first and second order kinetics for short times. It was suggested that the principal annealing mechanism was migration of lithium to a radiation induced defect with subsequent neutralization of the defect by combination with lithium. The effects of base lithium gradient were investigated. It was found that cells with negative base lithium gradients exhibited poor radiation resistance and performance compared to those with positive or no lithium gradients; the latter being preferred for overall performance and radiation resistance. M.G.

N80-15558*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RADIATION DAMAGE ANNEALING MECHANISMS AND POSSIBLE LOW TEMPERATURE ANNEALING IN SILICON SOLAR CELLS

Irving Weinberg and Clifford K. Swartz 1980 10 p refs Presented at 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE

(NASA-TM-81392; E-302) Avail: NTIS HC A02/MF A01 CSCL 10A

The defect responsible for reverse annealing in 2 ohm/cm n(+)/p silicon solar cells was identified. This defect, with energy level at e sub v + 0.30 eV was tentatively identified as a boron oxygen-vacancy complex. Results indicate that its removal could result in significant annealing for 2 ohm/cm and lower resistivity cells at temperatures as low as 200 C. These results were obtained by use of an expression derived from the Shockley-Read-Hall recombination theory which relates measured diffusion length ratios to relative defect concentrations and electron capture cross sections. The relative defect concentrations and one of the required capture cross sections are obtained from Deep Level Transient Spectroscopy. Four additional capture cross sections are obtained using diffusion length data and data from temperature dependent lifetime studied. These calculated results are in reasonable agreement with experimental data. M.G.

N80-15560*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CANDIDATE THERMAL ENERGY STORAGE TECHNOLOGIES FOR SOLAR INDUSTRIAL PROCESS HEAT APPLICATIONS

Edward R. Furman 1979 12 p refs Presented at Solar Industrial Process Heat Conf., Oakland, Calif., 31 Oct. - 2 Nov. 1979; sponsored by Solar Energy Res. Inst.

(Contract EC-77-A-31-1034)

(NASA-TM-81380; DOE/NASA/1034-79/6; E-285) Avail: NTIS HC A02/MF A01 CSCL 10A

A number of candidate thermal energy storage system elements were identified as having the potential for the successful application of solar industrial process heat. These elements which include storage media, containment and heat exchange are shown. R.C.T.

N80-15561*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

GLOBAL CALIBRATION OF TERRESTRIAL REFERENCE CELLS AND ERRORS INVOLVED IN USING DIFFERENT IRRADIANCE MONITORING TECHNIQUES

Henry B. Curtis 1980 12 p refs Presented at the 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE

(Contract DE-AI01-79ET-20485)

(NASA-TM-81393; DOE/NASA/20485-79/6; E-303) Avail: NTIS HC A02/MF A01 CSCL 10A

The feasibility of global calibration of terrestrial reference cells is discussed. A simple, accurate 'secondary' calibration technique based on ratios of test to reference cell currents measured in natural sunlight is described. Different techniques for monitoring incident irradiance during solar cell performance measurements are also examined and assessed, including the techniques of black-body detectors, calibrated reference cells, and the convolution of spectral response with solar irradiance. M.G.

N80-16453*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LARGE WIND TURBINE DESIGN CHARACTERISTICS AND R AND D REQUIREMENTS

Seymour Lieblein, ed. (Technical Report Services, Rocky River, Ohio) Dec. 1979 459 p refs Conf. held at Cleveland, 24-26 Apr. 1979; sponsored in part by DOE
(NASA-CP-2106; CONF-7904111) Avail: NTIS HC A20/MF A01 CSCL 10B

Detailed technical presentations on large wind turbine research and development activities sponsored by public and private organizations are presented. Both horizontal and vertical axis machines are considered with emphasis on their structural design. For individual titles, see N80-16454 through N80-16482.

N80-16455*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN EVOLUTION OF LARGE WIND TURBINE GENERATORS

David A. Spera *In its* Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 25-33 ref (For primary document see N80-16453 07-44)
Avail: NTIS HC A20/MF A01 CSCL 10B

During the past five years, the goals of economy and reliability have led to a significant evolution in the basic design--both external and internal--of large wind turbine systems. To show the scope and nature of recent changes in wind turbine designs, development of three types are described: (1) system configuration developments; (2) computer code developments; and (3) blade technology developments. R.E.S.

N80-16469*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STRUCTURAL ANALYSIS CONSIDERATIONS FOR WIND TURBINE BLADES

David A. Spera *In its* Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 211-224 refs (For primary document see N80-16453 07-44)
Avail: NTIS HC A20/MF A01 CSCL 10B

Approaches to the structural analysis of wind turbine blade designs are reviewed. Specifications and materials data are discussed along with the analysis of vibrations, loads, stresses, and failure modes. K.L.

N80-16470*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

BLADE DESIGN AND OPERATING EXPERIENCE ON THE MOD-OA 200 kW WIND TURBINE AT CLAYTON, NEW MEXICO

Bradford S. Linscott and Richard K. Shaltens *In its* Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 225-238 refs (For primary document see N80-16453 07-44)
Avail: NTIS HC A20/MF A01 CSCL 10B

Two 60 foot long aluminum wind turbine blades were operated for over 3000 hours on the MOD-OA wind turbine. The first signs of blade structural damage were observed after 400 hours of operation. Details of the blade design, loads, cost, structural damage, and repair are discussed. K.L.

N80-16472*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN, FABRICATION, AND TEST OF A STEEL SPAR WIND TURBINE BLADE

Timothy L. Sullivan, Paul J. Sirocky, Jr., and Larry A. Viterna *In its* Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 267-284 refs (For primary document see N80-16453 07-44)
Avail: NTIS HC A20/MF A01 CSCL 10B

The design and fabrication of wind turbine blades based on 60 foot steel spars are discussed. Performance and blade load information is given and compared to analytical prediction. In addition, performance is compared to that of the original MOD-O aluminum blades. Costs for building the two blades are given, and a projection is made for the cost in mass production. Design improvements to reduce weight and improve fatigue life are suggested. K.L.

N80-16480*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SIMULATION STUDIES OF MULTIPLE LARGE WIND TURBINE GENERATORS ON A UTILITY NETWORK

Leonard J. Gilbert and David M. Triezenberg (Purdue Univ.) *In its* Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 375-384 refs (For primary document see N80-16453 07-44)
Avail: NTIS HC A20/MF A01 CSCL 10B

The potential electrical problems that may be inherent in the inertia of clusters of wind turbine generators and an electric utility network were investigated. Preliminary and limited results of an analog simulation of two MOD-2 wind generators tied to an infinite bus indicate little interaction between the generators and between the generators and the bus. The system demonstrated transient stability for the conditions considered. A.R.H.

N80-16490*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

POTENTIAL PERFORMANCE IMPROVEMENT USING A REACTING GAS (NITROGIN TETROXIDE) AS THE WORKING FLUID IN A CLOSED BRAYTON CYCLE Final Report

Robert J. Stochl Dec. 1979 23 p refs
(Contract EX-76-A-29-1060)
(NASA-TM-79322; DOE/NASA/1060-79/3) Avail: NTIS HC A02/MF A01 CSCL 10B

The results of an analysis to estimate the performance that could be obtained by using a chemically reacting gas (nitrogen tetroxide) as the working fluid in a closed Brayton cycle are presented. Compared with data for helium as the working fluid, these results indicate efficiency improvements from 4 to 90 percent, depending on turbine inlet temperature, pressures, and gas residence time in heat transfer equipment. Author

N80-16494*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY ANALYSIS OF PERFORMANCE AND LOADS DATA FROM THE 2-MEGAWATT MOD-1 WIND TURBINE GENERATOR

D. A. Spera, L. A. Viterna, T. R. Richards, and [illegible] Neustadter 1979 16 p refs Presented at 4th Biennial Conf. and Workshop on Wind Energy Conversion Systems, Washington, D.C., 29-31 Oct. 1979; sponsored by DOE
(Contract EX-77-A-29-1010)
(NASA-TM-81408; DOE/NASA/1010-79/[illegible].2) Avail: NTIS HC A02/MF A01 CSCL 10A

Preliminary test data on output power versus wind speed, rotor blade loads, system dynamic behavior, and start-stop characteristics on the Mod-1 wind turbine generator are presented. These data were analyzed statistically and are compared with design predictions of system performance and loads. To date, the Mod-1 wind turbine generator has produced up to 1.5 MW of power, with a measured power versus wind speed curve which agrees closely with design. Blade loads were measured at wind speeds up to 14 m/s and also during rapid shutdowns. Peak transient loads during the most severe shutdowns are less than the design limit loads. On the inboard blade sections, fatigue loads are approximately equal to the design cyclic loads. On the outboard blade sections, however, measured cyclic loads cells is discussed. A simple, accurate 'secondary' calibration technique based on ratios of test to reference cell currents measured in natural sunlight is described. Different techniques for monitoring incident irradiance during solar cell performance measurements are also examined and assessed, including the techniques of black-body detectors, calibrated reference cells, and the convolution of spectral response with solar irradiance. M.G.

N80-16453*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LARGE WIND-TURBINE DESIGN CHARACTERISTICS AND R AND D REQUIREMENTS
Seymour Lieblein, ed. (Technical Report Services, Rocky River, Ohio) Dec. 1979 459 p refs Conf. held at Cleveland, 24-26 Apr. 1979; sponsored in part by DOE
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Detailed technical presentations on large wind turbine research and development activities sponsored by public and private organizations are presented. Both horizontal and vertical axis machines are considered with emphasis on their structural design. For individual titles, see N80-16454 through N80-16482.

N80-16455*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
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David A. Spera *In its* Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 25-33 ref (For primary document see N80-16453 07-44)
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During the past five years, the goals of economy and reliability have led to a significant evolution in the basic design--both external and internal--of large wind turbine systems. To show the scope and nature of recent changes in wind turbine designs, development of three types are described: (1) system configuration developments; (2) computer code developments; and (3) blade technology developments. R.E.S.

N80-16469*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STRUCTURAL ANALYSIS CONSIDERATIONS FOR WIND TURBINE BLADES
David A. Spera *In its* Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 211-224 refs (For primary document see N80-16453 07-44)
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Approaches to the structural analysis of wind turbine blade designs are reviewed. Specifications and materials data are discussed along with the analysis of vibrations, loads, stresses, and failure modes. K.L.

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BLADE DESIGN AND OPERATING EXPERIENCE ON THE MOD-OA 200 kW WIND TURBINE AT CLAYTON, NEW MEXICO
Bradford S. Linscott and Richard K. Shaltens *In its* Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 225-238 refs (For primary document see N80-16453 07-44)
Avail: NTIS HC A20/MF A01 CSCL 10B

Two 60 foot long aluminum wind turbine blades were operated for over 3000 hours on the MOD-OA wind turbine. The first signs of blade structural damage were observed after 400 hours of operation. Details of the blade design, loads, cost, structural damage, and repair are discussed. K.L.

N80-16472*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN, FABRICATION, AND TEST OF A STEEL SPAR WIND TURBINE BLADE
Timothy L. Sullivan, Paul J. Sirocky, Jr., and Larry A. Viterna *In its* Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 267-284 refs (For primary document see N80-16453 07-44)
Avail: NTIS HC A20/MF A01 CSCL 10B

The design and fabrication of wind turbine blades based on 60 foot steel spars are discussed. Performance and blade load information is given and compared to analytical prediction. In addition, performance is compared to that of the original MOD-O aluminum blades. Costs for building the two blades are given, and a projection is made for the cost in mass production. Design improvements to reduce weight and improve fatigue life are suggested. K.L.

N80-16480*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SIMULATION STUDIES OF MULTIPLE LARGE WIND TURBINE GENERATORS ON A UTILITY NETWORK
Leonard J. Gilbert and David M. Triezenberg (Purdue Univ.) *In its* Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 375-384 refs (For primary document see N80-16453 07-44)
Avail: NTIS HC A20/MF A01 CSCL 10B

The potential electrical problems that may be inherent in the inertia of clusters of wind turbine generators and an electric utility network were investigated. Preliminary and limited results of an analog simulation of two MOD-2 wind generators tied to an infinite bus indicate little interaction between the generators and between the generators and the bus. The system demonstrated transient stability for the conditions considered. A.R.H.

N80-16490*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POTENTIAL PERFORMANCE IMPROVEMENT USING A REACTING GAS (NITROGIN TETROXIDE) AS THE WORKING FLUID IN A CLOSED BRAYTON CYCLE Final Report
Robert J. Stochl Dec. 1979 23 p refs
(Contract EX-76-A-29-1060)
(NASA-TM-79322; DOE/NASA/1060-79/3) Avail: NTIS HC A02/MF A01 CSCL 10B

The results of an analysis to estimate the performance that could be obtained by using a chemically reacting gas (nitrogen tetroxide) as the working fluid in a closed Brayton cycle are presented. Compared with data for helium as the working fluid, these results indicate efficiency improvements from 4 to 90 percent, depending on turbine inlet temperature, pressures, and gas residence time in heat transfer equipment. Author

N80-16494*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY ANALYSIS OF PERFORMANCE AND LOADS DATA FROM THE 2-MEGAWATT MOD-1 WIND TURBINE GENERATOR
D. A. Spera, L. A. Viterna, T. R. Richards, and H. E. Neustadter 1979 16 p refs Presented at 4th Biennial Conf. and Workshop on Wind Energy Conversion Systems, Washington, D.C., 29-31 Oct. 1979; sponsored by DOE
(Contract EX-77-A-29-1010)
(NASA-TM-81408; DOE/NASA/1010-79/5; E-322) Avail: NTIS HC A02/MF A01 CSCL 10A

Preliminary test data on output power versus wind speed, rotor blade loads, system dynamic behavior, and start-stop characteristics on the Mod-1 wind turbine generator are presented. These data were analyzed statistically and are compared with design predictions of system performance and loads. To date, the Mod-1 wind turbine generator has produced up to 1.5 MW of power, with a measured power versus wind speed curve which agrees closely with design. Blade loads were measured at wind speeds up to 14 m/s and also during rapid shutdowns. Peak transient loads during the most severe shutdowns are less than the design limit loads. On the inboard blade sections, fatigue loads are approximately equal to the design cyclic loads. On the outboard blade sections, however, measured cyclic loads are significantly larger than design values, but they do not appear to exceed fatigue allowable loads as yet. R.E.S.

N80-18554*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OVERVIEW OF A STIRLING ENGINE TEST PROJECT
Jack G. Slaby 1980 27 p refs Proposed for presentation at 5th Intern. Automotive Propulsion Systems Symp., Dearborn, Mich., 14-18 Apr. 1980
(Contract EC-77-A-31-1040)
(NASA-TM-81442; DOE/NASA/1040-80/12; E-362) Avail: NTIS HC A03/MF A01 CSCL 10B

Tests were conducted on three Stirling engines ranging in size from 1.33 to 53 horsepower (1 to 40 kW). The tests were directed toward developing alternative, backup component concepts to improve engine efficiency and performance or to reduce costs. Some of the activities included investigating attractive concepts and materials for cooler-regenerator units, installing a jet impingement device on a Stirling engine to determine its potential for improved engine performance, and presenting performance maps for initial characterization of Stirling engines. The experiment results of the tests are presented along with predictions of results of future tests to be conducted on the Stirling engines. R.E.S.

N80-18555*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLEXIBLE FORMULATED PLASTIC SEPARATORS FOR ALKALINE BATTERIES Patent Application
D. W. Scheibley, J. M. Bozek, and D. G. Soltis, inventors (to NASA) Filed 28 Sep. 1979 10 p
(NASA-Case-LEW-12363-4; US-Patent-Appl-SN-079914) Avail: NTIS HC A02/MF A01 CSCL 10C

A flexible separator for alkaline batteries is disclosed. The separator is comprised of a coating which is applied to a nonwoven porous substrate such as sheets or mats of asbestos or other materials which are inert with respect to the alkaline electrolyte of the battery. The coating material comprises a polyphenylene oxide polymer, an organic additive and inorganic and organic fillers which comprise 55% by volume or less of the coating material. Preferably, at least one inorganic filler material which is reactive with the electrolyte is included to produce desirable pores in the coating. The organic additive is a polymeric polyester material which is hydrolyzed by the alkaline electrolyte to improve conductivity of the coating. NASA

N80-18556*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLEXIBLE FORMULATED PLASTIC SEPARATORS FOR ALKALINE BATTERIES Patent Application
D. W. Scheibley, J. M. Bozek, and D. G. Soltis, inventors (to NASA) Filed 19 Jul. 1979 10 p
(NASA-Case-LEW-12363-3; US-Patent-Appl-SN-058658) Avail NTIS HC A02/MF A01 CSCL 10C

A flexible separator for alkaline batteries is disclosed. The separator is comprised of a coating which is applied to a nonwoven porous substrate such as sheets or mats of asbestos or other materials which are inert with respect to the alkaline electrolyte of the battery. The coating material is comprised of a polyphenylene oxide polymer, an organic additive and inorganic, and organic fillers which comprise 55% by volume or less of the coating material. Preferably, at least one inorganic filler material which is reactive with the electrolyte is included to produce desirable pores in the coating. The organic additive is a polymeric polyester material which is hydrolyzed by the alkaline electrolyte to improve conductivity of the coating. NASA

N80-18557*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CATALYST SURFACES FOR THE CHROMOUS/CHROMIC REDOX COUPLE Patent Application
Jose D. Giner (Giner, Inc.) and Kathleen J. Cahill, inventors (to NASA) (Giner, Inc.) Filed 27 Jul. 1979 15 p Sponsored by NASA
(NASA-Case-Lew-13148-2; US-Patent-Appl-SN-061555) Avail: NTIS HC A02/MF A01 CSCL 10A

An electricity producing cell of the reduction-oxidation type is disclosed. The cell is divided into two compartments by a membrane and each compartment contains a solid inert electrode. A ferrous/ferric couple in a chloride solution serves as a cathode fluid which is circulated through one of the compartments to produce a positive electric potential disposed therein. A chromic/chromous couple in a chloride solution serves as an anode fluid which is circulated through the second compartment to produce a negative potential on an electrode disposed therein. The electrode is an electrically conductive, inert material plated with copper, silver or gold. A thin layer of lead plates onto the copper, silver or gold layer when the cell is being charged, the lead ions being available from lead chloride which has been added to the anode fluid. If the REDOX cell is then discharged, the current flows between the electrodes causing the lead to deplate from the negative electrode and the metal coating on the electrode will act as a catalyst to cause increased current density. NASA

N80-18563*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ENGINEERING EVALUATION OF A SODIUM HYDROXIDE THERMAL ENERGY STORAGE MODULE Final Report
Donald G. Perdue and Larry H. Gordon Feb. 1980 22 p refs
(Contract EC-77-A-31-1034)
(NASA-TM-81417; DOE/NASA/1034-80/7; E-338) Avail: NTIS HC A02/MF A01 CSCL 10A

An engineering evaluation of thermal energy storage prototypes was performed in order to assess the development status of latent heat storage media. The testing and the evaluation of a prototype sodium hydroxide module is described. This module stored off-peak electrical energy as heat for later conversion to domestic hot water needs. R.E.S.

N80-19613*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TEETERED, TIP-CONTROLLED ROTOR: PRELIMINARY TEST RESULTS FROM MOD-0 100-kW EXPERIMENTAL WIND TURBINE
J. C. Glasgow and D. R. Miller 1980 16 p refs Presented at Wind Energy Conf., Boulder, Colo., 9-11 Apr. 1980; sponsored by Am. Inst. of Aeron. and Astronautics and the Midwest Res. Inst.
(Contract EX-76-I-01-1028)
(NASA-TM-81445; DOE/NASA/1028-80/26; E-365) Avail: NTIS HC A02/MF A01 CSCL 10B

Results of tests conducted using the MOD-0 100 kW experimental wind turbine are evaluated. The teetered rotor significantly decreased loads on the yaw drive mechanism and reduced blade cyclic flapwise bending moments by 25 percent at the 20 percent span location when compared to the rigid hub rotor. The teetered hub performed well, but impacted the teeter stops on occasion as wind speed and/or direction varied rapidly. The tip-controlled rotor performed satisfactorily with some expected loss of control when compared to the full span pitchable blade. The performance results indicate that a review of techniques used to calculate rotor power is in order. K.L.

N80-19614*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INSTALLATION AND CHECKOUT OF THE DOE/NASA MOD-1 2000-kW WIND TURBINE GENERATOR
Richard L. Puthoff and John L. Collins 1980 25 p refs Presented at Wind Energy Conf., Boulder, Colo. 9-11 Apr. 1980; sponsored by Am. Inst. of Aeron. and Astronautics and the Midwest Res. Inst.
(Contract EX-77-A-29-1010)
(NASA-TM-81444; DOE/NASA/1010-80/6; E-364) Avail: NTIS HC A02/MF A01 CSCL 10B

The Mod-1 machine was assembled without the blades, tested, and sent to the site at Boone, North Carolina for erection. The blades were transported directly to the site. A series of checkout tests were then conducted to evaluate performance and loads. The results of these tests compared well with the design data. K.L.

N80-19626*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 1: SUMMARY
Gerald J. Barna, Raymond K. Burns, and Gary D. Sagerman Jan. 1980 89 p
(Contract EC-77-A-31-1062)
(NASA-TM-81400; DOE/NASA/1062-80/4; E-312) Avail: NTIS HC A05/MF A01 CSCL 10B

Various advanced energy conversion systems that can use coal or coal-derived fuels for industrial cogeneration applications were compared to provide information needed by DOE to establish research and development funding priorities for advanced-technology systems that could significantly advance the use of coal or coal-derived fuels in industrial cogeneration. Steam turbines, diesel engines, open-cycle gas turbines, combined cycles, closed-cycle gas turbines, Stirling engines, phosphoric acid fuel cells, molten carbonate fuel cells, and thermionics were studied with technology advancements appropriate for the 1985-2000 time period. The various advanced systems were compared and evaluated for wide diversity of representative industrial plants on the basis of fuel energy savings, annual energy cost savings, emissions savings, and rate of return on investment as compared with purchasing electricity from a utility and providing process heat with an on-site boiler. Also included in the comparisons and evaluations are results extrapolated to the national level. F.O.S.

N80-21837*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLAME TUBE PARAMETRIC STUDIES FOR CONTROL OF FUEL BOUND NITROGEN USING RICH-LEAN TWO-STAGE COMBUSTION
Donald F. Schultz and Gary Wolfbrandt 1980 25 p refs Presented at Western States Sect. of the Combust. Inst. of Spring Meeting, Irvine, Calif., 21-22 Apr. 1980
(Contract EF-77-A-01-2593)
(NASA-TM-81472; DOE/NASA/2593-80/15; E-405) Avail: NTIS HC A02/MF A01 CSCL 21B

An experimental parametric study of rich-lean two-stage combustion in a flame tube is described and approaches for minimizing the conversion of fuel-bound nitrogen to nitrogen oxides in a premixed, homogeneous combustion system are evaluated. Air at 672 K and 0.48 MPa was premixed with fuel blends of propane, toluene, and pyridine at primary equivalence ratios ranging from 0.5 to 2.0 and secondary equivalence ratios of 0.5 to 0.7. Distillates of SRC-II, a coal syncrude, were also tested. The blended fuels were proportioned to vary fuel hydrogen composition from 9.0 to 18.3 weight percent and fuel nitrogen composition from zero to 1.5 weight percent. Rich-lean combustion proved effective in reducing fuel nitrogen to NO sub x conversion; conversion rates up to 10 times lower than those normally produced by single-stage combustion were achieved. The optimum primary equivalence ratio, where the least NO sub x was produced and combustion efficiency was acceptable, shifted between 1.4 and 1.7 with changes in fuel nitrogen content and fuel hydrogen content. Increasing levels of fuel nitrogen content lowered the conversion rate, but not enough to avoid higher NO sub x emissions as fuel nitrogen increased. M.G.

N80-22776*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LITERATURE SURVEY OF PROPERTIES OF SYNFUELS DERIVED FROM COAL Interim Report
Thaine W. Reynolds, Richard W. Niedzwiecki, and John S. Clark Feb. 1980 162 p refs
(Contract EF-77-A-01-2593)
(NASA-TM-79243; DOE/NASA/2593-79/8; E-150) Avail: NTIS HC A08/MF A01 CSCL 21D

A literature survey of the properties of synfuels for ground-based gas turbine applications is presented. Four major concepts for converting coal into liquid fuels are described: solvent extraction, catalytic liquefaction, pyrolysis, and indirect liquefaction. Data on full range syncrudes, various distillate cuts, and upgraded products are presented for fuels derived from various processes, including H-coal, synthoil, solvent-refined coal, donor solvent, zinc chloride hydrocracking, co-steam, and flash pyrolysis. Some typical ranges of data for coal-derived low Btu gases are also presented. R.E.S.

N80-22777*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADVANCED SCREENING OF ELECTRODE COUPLES
J. Giner and K. Cahill Feb. 1980 56 p refs
(Contract NAS3-20794; EC-77-A-31-1002)
(NASA-CR-159738; DOE/NASA/0794-80/1) Avail: NTIS HC A04/MF A01 CSCL 10B

The chromium (Cr(3+)/Cr(2+)) redox couple (electrolyte and electrode) was investigated to determine its suitability as negative electrode for the iron (Fe(3+)/Fe(2+))-chromium (Cr(3+)/Cr(2+)) redox flow battery. Literature search and laboratory investigation established that the solubility and stability of aqueous acidic solutions of chromium(3) chloride and chromium(2) chloride are sufficient for redox battery application. Four categories of electrode materials were tested; namely, metals and metalloid materials (elements and compounds), alloys, plated materials, and Teflon-bonded materials. In all, the relative performance of 26 candidate electrode materials was evaluated on the basis of slow scan rate linear sweep voltammetry in stirred solution. No single material tested gave both acceptable anodic an acceptable cathodic performance. However, the identification of lead as a good cathodic electrocatalyst and gold as a good anodic electrocatalyst led to the invention of the lead/gold combination electrocatalyst. This type of catalyst can be fabricated in several ways and appears to offer the advantages of each metal without the disadvantages associated with their use as single materials. This lead/gold electrocatalyst was tested by NASA-Lewis Research Center in complete, flowing, redox batteries comprising a stack of several cells. A large improvement in the battery's coulombic and energy efficiency was observed. F.O.S.

N80-22788*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THERMAL ENERGY STORAGE: FOURTH ANNUAL REVIEW MEETING
Mar. 1980 650 p refs Meeting held at Tysons Corner, Va., 3-4 Dec. 1979; sponsored by DOE
(NASA-CP-2125; E-428; CONF-791232) Avail: NTIS HC A99/MF A01 CSCL 10C

The development of low cost thermal energy storage technologies is discussed in terms of near term oil savings, solar energy applications, and dispersed energy systems for energy conservation policies. Program definition and assessment and research and technology development are considered along with industrial storage, solar thermal power storage, building heating and cooling, and seasonal thermal storage. A bibliography on seasonal thermal energy storage emphasizing aquifer thermal energy is included. For individual titles, see N80-22789 through N80-22829.

N80-22790*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROGRAM DEFINITION AND ASSESSMENT OVERVIEW
Larry H. Gordon *In its* Thermal Energy Storage Mar. 1980 p 38-41 refs (For primary document see N80-22788 13-44)
Avail: NTIS HC A99/MF A01 CSCL 10B

The implementation of a program level assessment of thermal energy storage technology thrusts for the near and far term to assure overall coherent energy storage program is considered. The identification and definition of potential thermal energy storage applications, definition of technology requirements, and appropriate market sectors are discussed along with the necessary coordination, planning, and preparation associated with program reviews, workshops, multi-year plans and annual operating plans for the major laboratory tasks. J.M.S.

N80-22795*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INDUSTRIAL STORAGE APPLICATIONS OVERVIEW
Rudolph A Duscha *In its* Thermal Energy Storage Mar 1980 p 85-94 refs (For primary document see N80-22788 13-44)
Avail NTIS HC A99/MF A01 CSCL 10B

The implementation of a technology demonstration for the food processing industry, development and technology demonstrations for selected near-term, in-plant applications and advanced industrial applications of thermal energy storage are overviewed. R.E.S.

N80-22797*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COLLECTION AND DISSEMINATION OF TES SYSTEM INFORMATION FOR THE PAPER AND PULP INDUSTRY
M W. Dietrich and Howard Edde (Edde (Howard), Inc., Bellevue, Wash.) *In its* Thermal Energy Storage Mar. 1980 p 105-111 (For primary document see N80-22788 13-44)
(Contract DEN3-190)
Avail NTIS HC A99/MF A01 CSCL 10B

A survey of U.S. and international paper and pulp mills using thermal energy storage (TES) systems as a part of their production processes was conducted to obtain sufficient operating data to conduct a benefits analysis encompassing: (1) an energy conservation assessment, (2) an economic benefits analysis, and (3) an environmental impact assessment. An information dissemination plan was then proposed to effectively present the benefits of TES to the U.S. paper and pulp industry. R.E.S.

N80-23769*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CELL MODULE AND FUEL CONDITIONER Quarterly Report, Jan. Mar. 1980
D. Q. Hoover, Jr. Apr. 1980 87 p
(Contracts DEN3-161; DE-AI03-79ET-11272)
(NASA-CR-159875; DOE/NASA/0161-2; QR-2) Avail: NTIS HC A05/MF A01 CSCL 10A

Stack tests indicate that the discrepancies between calculated and measured temperature profiles are due to reactant cross-over and a lower than expected thermal conductivity of cells. Preliminary results indicate that acceptable contact resistance between cooling plane halves can be achieved without the use of paper. The preliminary design of the enclosure, definition of required labor and equipment for manufacturing repeating components, and the assembly procedures for the benchwork design were developed. Fabrication of components for a second 5-cell stack of the MK-2 design and a second 23-cell stack of the MK-1 design was started. The definition of water and fuel for the reforming subsystem was developed along with a preliminary definition of the control system for the subsystem. The construction and shakedown of the differential catalytic reactor was completed and testing of the first catalyst initiated. R.E.S.

N80-23777*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REDOX STORAGE SYSTEMS FOR SOLAR APPLICATIONS
Norman H. Hagedorn and Lawrence H. Thaller 1980 28 p refs Proposed for presentation at Power Sources Conf., Brighton, England, 15-18 Sep. 1980
(Contract EF-77-A-31-1002)
(NASA-TM-81464; DOE/NASA/1002-80/5; E-383) Avail: NTIS HC A03/MF A01 CSCL 10A

The NASA Redox energy storage system is described. The system is based on soluble aqueous iron and chromium chloride redox couples. The needed technology advances in the two elements (electrodes and membranes) that are key to its technological feasibility have been achieved and system development has begun. The design, construction, and test of a 1 kilowatt system integrated with a solar photovoltaic array is discussed. R.E.S.

N80-23778*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE OPTIMIZATION AIR SEPARATION PLANTS FOR COMBINED CYCLE MHD-POWER PLANT APPLICATIONS
Albert J. Juhasz, Helmut Springmann, and Ralph Greenberg 1980 11 p refs Presented at the 7th Intern. Conf. on MHD Elec. Power Generation, Cambridge, Mass., 16-20 Jun. 1980
(Contracts DEN3-165; EF-77-A-01-2674)
(NASA-TM-81510; DOE/NASA/2674-80/10) Avail: NTIS HC A02/MF A01 CSCL 10B

Some of the design approaches being employed during a current supported study directed at developing an improved air separation process for the production of oxygen enriched air for magnetohydrodynamics (MHD) combustion are outlined. The ultimate objective is to arrive at conceptual designs of air separation plants, optimized for minimum specific power consumption and capital investment costs, for integration with MHD combined cycle power plants. R.E.S.

N80-23779*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE EFFECT OF CATALYST LENGTH AND DOWNSTREAM REACTOR DISTANCE ON CATALYTIC COMBUSTOR PERFORMANCE
David Anderson 1980 24 p refs Presented at the 4th Workshop on Catalytic Combust., Cincinnati, 14-15 May 1980; sponsored by EPA
(Contract EC-77-A-31-1040)
(NASA-TM-81475; DOE/NASA/1040-80/14; E-409) Avail: NTIS HC A02/MF A01 CSCL 10B

A study was made to determine the effects on catalytic combustor performance which resulted from independently varying the length of a catalytic reactor and the length available for gas-phase reactions downstream of the catalyst. Monolithic combustion catalysts from three manufacturers were tested in a combustion test rig with no. 2 diesel fuel. Catalytic reactor lengths of 2.5 and 5.4 cm, and downstream gas-phase reaction distances of 7.3, 12.4, 17.5, and 22.5 cm were evaluated. Measurements of carbon monoxide, unburned hydrocarbons, nitrogen oxides, and pressure drop were made. The catalytic-reactor pressure drop was less than 1 percent of the upstream total pressure for all test configurations and test conditions. Nitrogen oxides and unburned hydrocarbons emissions were less than 0.25 g NO_2/kg fuel and 0.6 g HC/kg fuel, respectively. The minimum operating temperature (defined as the adiabatic combustion temperature required to obtain carbon monoxide emissions below a reference level of 13.6 g CO/kg fuel) ranged from 1230 K to 1500 K for the various conditions and configurations tested. The minimum operating temperature decreased with increasing total (catalytic-reactor-plus-downstream-gas-phase-reactor-zone) residence time but was independent of the relative times spent in each region when the catalytic-reactor residence time was greater than or equal to 1.4 ms. R.E.S.

N80-23780*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUMMARY AND EVALUATION OF THE PARAMETRIC STUDY OF POTENTIAL EARLY COMMERCIAL MHD POWER PLANTS (PSPEC)
Peter J. Staigner and John M. Abbott 1980 11 p refs Presented at the 7th Intern. Conf. on Magnetohydrodyn. Elec. Generation, Cambridge, Mass., 16-20 Jun. 1980; sponsored by the Symp. on the Eng. Aspects of Magnetohydrodynam., Inc.
(Contract EF-77-A-31-2674)
(NASA-TM-81497; DOE/NASA/2674-80/9; E-434) Avail: NTIS HC A02/MF A01 CSCL 10B

Two parallel contracted studies were conducted. Each contractor investigated three base cases and parametric variations about these base cases. Each contractor concluded that two of the base cases (a plant using separate firing of an advanced high temperature regenerative air heater with fuel from an advanced coal gasifier and a plant using an intermediate temperature metallic recuperative heat exchanger to heat oxygen enriched combustion air) were comparable in both performance and cost of electricity. The contractors differed in the level of their cost estimates with the capital cost estimates for the MHD topping cycle and the magnet subsystem in particular accounting for a significant part of the difference. The impact of the study on the decision to pursue a course which leads to an oxygen enriched plant as the first commercial MHD plant is described. R.E.S.

N80-24756*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN ELECTRIC VEHICLE PROPULSION SYSTEM'S IMPACT ON BATTERY PERFORMANCE: AN OVERVIEW
John M. Bozek, John J. Smithrick, Robert C. Cataldo, and John G. Ewashinka 1980 10 p refs Presented at the 3d Intern. Elec. Vehicle Exposition and Conf., St. Louis, 20-22 May 1980
(Contract EC-77-A-31-1044)
(NASA-TM-81515; DOE/NASA/1044-7; E-459) Avail: NTIS HC A02/MF A01 CSCL 10B

The performance of two types of batteries, lead-acid and nickel-zinc, was measured as a function of the charging and discharging demands anticipated from electric vehicle propulsion systems. The benefits of rapid high current charging were mixed; although it allowed quick charges, the energy efficiency was reduced. For low power (overnight) charging the current wave shapes delivered by the charger to the battery tended to have no effect on the battery cycle life. The use of chopper speed controllers with series traction motors resulted in a significant reduction in the energy available from a battery whenever the motor operates at part load. The demand placed on a battery by an electric vehicle propulsion system containing electrical regenerative braking confirmed significant improvment in short term performance of the battery. R.E.S.

N80-25779*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THERMAL ENERGY STORAGE
Jun. 1980 77 p refs
(Contract EC-77-A-31-1034)
(NASA-TM-81514; E-457; DOE/NASA/1034-8) Avail: NTIS HC A05/MF A01 CSCL 10C

The planning and implementation of activities associated with lead center management role and the technical accomplishments pertaining to high temperature thermal energy storage subsystems are described. Major elements reported are: (1) program definition and assessment; (2) research and technology development; (3) industrial storage applications; (4) solar thermal power storage applications; and (5) building heating and cooling applications. R.E.S.

N80-25780*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PULSE CHARGING OF LEAD-ACID TRACTION CELLS
John J. Smithrick May 1980 22 p refs
(Contract EC-77-A-31-1044)
(NASA-TM-81513; DOE/NASA/1044-6; E-454) Avail: NTIS HC A02/MF A01 CSCL 10C

Pulse charging, as a method of rapidly and efficiently charging 300 amp-hour lead-acid traction cells for an electric vehicle application was investigated. A wide range of charge pulse current square waveforms were investigated and the results were compared to constant current charging at the time averaged pulse current values. Representative pulse current waveforms were: (1) positive waveform-peak charge pulse current of 300 amperes (amps), discharge pulse-current of zero amps, and a duty cycle of about 50%; (2) Romanov waveform-peak charge pulse current of 300 amps, peak discharge pulse current of 15 amps, and a duty of 50%; and (3) McCulloch waveform peak charge pulse current of 193 amps, peak discharge pulse current of about 575 amps, and a duty cycle of 94%. Experimental results indicate that on the basis of amp-hour efficiency, pulse charging offered no significant advantage as a method of rapidly charging 300 amp-hour lead-acid traction cells when compared to constant current charging at the time average pulse current value. There were, however, some disadvantages of pulse charging in particular a decrease in charge amp-hour and energy efficiencies and an increase in cell electrolyte temperature. The constant current charge method resulted in the best energy efficiency with no significant sacrifice of charge time or amp-hour output. Whether or not pulse charging offers an advantage over constant current charging with regard to the cell charge/discharge cycle life is unknown at this time. R.E.S.

N80-27799*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ENGINEERING TEST FACILITY DESIGN DEFINITION
R. W. Bercaw and G. R. Seikel 20 Jun. 1980 16 p refs Presented at 7th Intern. Conf. on Magnetohydrodynamic Elect. Power Generation, Cambridge, Mass., 16-20 Jun. 1980; sponsored by Symp. on the Eng. Aspects of Magnetohydrodynamics, Inc.
(Contract EF-77-A-01-2674)
(NASA-TM-81499; DOE/NASA/2674-11; E-436) Avail: NTIS HC A02/MF A01 CSCL 10A

The Engineering Test Facility (ETF) is the major focus of the Department of Energy (DOE) Magnetohydrodynamics (MHD) Program to facilitie commercialization and to demonstrate the commercial operability of MHD/steam electric power. The ETF will be a fully integrated commercial prototype MHD power plant with a nominal output of 200 MW sub e. Performance of this plant is expected to meet or surpass existing utility standards for fuel, maintenance, and operating costs; plant availability; load following; safety; and durability. It is expected to meet all applicable environmental regulations. The current design concept conforming to the general definition, the basis for its selection, and the process which will be followed in further defining and updating the conceptual design. Author

N80-27804*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT ON COMBINED CYCLE EFFICIENCY OF STACK GAS TEMPERATURE CONSTRAINTS TO AVOID ACID CORROSION Final Report
Joseph J. Nainiger Jul. 1980 16 p refs
(Contract EF-77-A-01-2593)
(NASA-TM-81531; DOE/NASA/2593-17; E-483) Avail: NTIS HC A02/MF A01 CSCL 10B

To avoid condensation of sulfuric acid in the gas turbine exhaust when burning fuel oils contaning sulfur, the exhaust stack temperature and cold-end heat exchanger surfaces must be kept above the condensation temperature. Raising the exhaust stack temperature, however, results in lower combined cycle efficiency compared to that achievable by a combined cycle burning a sulfur-free fuel. The maximum difference in efficiency between the use of sulfur-free and fuels containing 0.8 percent sulfur is found to be less than one percentage point. The effect of using a ceramic thermal barrier coating (TBC) and a fuel containing sulfur is also evaluated. The combined-cycle efficiency gain using a TBC with a fuel containing sulfur compared to a sulfur-free fuel without TBC is 0.6 to 1.0 percentage points with air-cooled gas turbines and 1.6 to 1.8 percentage points with water-cooled gas turbines. Author

N80-27805*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPACT OF PROPULSION SYSTEM R AND D ON ELECTRIC VEHICLE PERFORMANCE AND COST
Harvey J. Schwartz and Andrew L. Gordan 22 May 1980 16 p refs Presented at 3d Intern. Electric Vehicle Exposition and Conf., St. Louis, 20-22 May 1980
(Contract EC-77-A-31-1044)
(NASA-TM-81548; DOE/NASA/1044-9; E-504) Avail: NTIS HC A02/MF A01 CSCL 10B

The efficiency, weight, and manufacturing cost of the propulsion subsystem (motor, motor controller, transmission, and differential, but excluding the battery) are major factors in the purchase price and cost of ownership of a traffic-compatible electric vehicle. The relative impact of each was studied, and the conclusions reached are that propulsion system technology advances can result in a major reduction of the sticker price of an electric vehicle and a smaller, but significant, reduction in overall cost of ownership. L.F.M.

N80-28859*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. Energy Technology Operation.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY

(CTAS). VOLUME 2: ANALYTICAL APPROACH Final Report
H. E. Gerlaugh, E. W. Hall, D. H. Brown, R. R. Priestley, and W. F. Knightly May 1980 106 p refs
(Contract DEN3-31)
(NASA-CR-159766; DOE/NASA/0031-80-2; GE80ETO10-Vol-2) Avail: NTIS HC A06/MF A01 CSCL 10B

The use of various advanced energy conversion systems were compared with each other and with current technology systems for their savings in fuel energy, costs, and emissions in individual plants and on a national level. The ground rules established by NASA and assumptions made by the General Electric Company in performing this cogeneration technology alternatives study are presented. The analytical methodology employed is described in detail and is illustrated with numerical examples together with a description of the computer program used in calculating over 7000 energy conversion system-industrial process applications. For Vol. 1, see N80-24797. R.E.S.

N80-29862*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RAPPORTEUR REPORT: MHD ELECTRIC POWER PLANTS
George R. Seikel 1980 17 p Presented at 7th Intern. Conf. on MHD Elec. Power Generation, Cambridge, Mass., 16-20 Jun. 1980
(Contract EF-77-A-01-2674)
(NASA-TM-81554; DOE/NASA/2674-12; E-516) Avail: NTIS HC A02/MF A01 CSCL 10B

Five US papers from the Proceedings of the Seventh International Conference on MHD Electrical Power Generation at the Massachusetts Institute of Technology are summarized. Results of the initial parametric phase of the US effort on the study of potential early commercial MHD plants are reported and aspects of the smaller commercial prototype plant termed the Engineering Test Facility are discussed. The alternative of using a disk geometry generator rather than a linear generator in baseload MHD plants is examined. Closed-cycle as well as open-cycle MHD plants are considered. A.R.H.

N80-29863*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GAS PHASE OXIDATION DOWNSTREAM OF A CATALYTIC COMBUSTOR
James S. Tien (Case Western Reserve Univ.) and David N. Anderson 1979 13 p refs Presented at 13th Middle Atlantic Regional Meeting of the ACS, West Long Branch, N.J., 19-23 Mar. 1979
(Contract EC-77-A-31-1040)
(NASA-TM-81551; DOE/NASA/1040-16; E-512) Avail: NTIS HC A02/MF A01 CSCL 10A

Effect of the length available for gas-phase reactions downstream of the catalytic reactor on the emission of CO and unburned hydrocarbons was investigated. A premixed, pre-vaporized propane/air feed to a 12/cm/diameter catalytic/reactor test section was used. The catalytic reactor was made of four 2.5 cm long monolithic catalyst elements. Four water cooled gas sampling probes were located at positions between 0 and 22 cm downstream of the catalytic reactor. Measurements of unburned hydrocarbon, CO, and CO_2 were made. Tests were performed with an inlet air temperature of 800 K, a reference velocity of 10 m/s, pressures of 3 and 600,000 Pa, and fuel air equivalence ratios of 0.14 to 0.24. For very lean mixtures, hydrocarbon emissions were high and CO continued to be formed downstream of the catalytic reactor. At the highest equivalence ratios tested, hydrocarbon levels were much lower and CO was oxidized to CO_2 in the gas phase downstream. To achieve acceptable emissions, a downstream region several times longer than the catalytic reactor could be required. R.K.G.

N80-32858*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LARGE WIND TURBINES: A UTILITY OPTION FOR THE GENERATION OF ELECTRICITY
W. H. Robbins, R. L. Thomas, and D. H. Baldwin 1980 18 p refs Presented at the Am. Power Conf., Chicago, 21-23 Apr. 1980; sponsored by Illinois Inst. of Tech.; presented at the Ann. Solar Energy Program Rev., Rockport, Maine, 26-28 Aug. 1980; sponsored by Electric Power Research Inst.
(Contract DE-AI01-79ET-23139)
(NASA-TM-81502; DOE/NASA/23139-1; E-440) Avail: NTIS HC A02/MF A01 CSCL 10B

The wind resource is such that wind energy generation has the potential to save 6-7 quads of energy nationally. Thus, the Federal Government is sponsoring and encouraging the development of cost effective and reliable wind turbines. One element of the Federal Wind Energy Programs, Large Horizontal Axis Wind Turbine Development, is managed by the NASA Lewis Research Center for the Department of Energy. There are several ongoing wind system development projects oriented primarily toward utility application within this program element. In addition, a comprehensive technology program supporting the wind turbine development projects is being conducted. An overview is presented of the NASA activities with emphasis on application of large wind turbines for generation of electricity by utility systems. Author

N80-33857*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TOROIDAL CELL AND BATTERY Patent Application
William J. Nagle, inventor (to NASA) Filed 28 Mar. 1980 13 p
(NASA-Case-LEW-12918-1; US-Patent-Appl-SN-134855) Avail: NTIS HC A02/MF A01 CSCL 10C

A toroidal cell is disclosed which includes a wound core disposed within a pair of toroidal channel shaped electrodes separated by nylon insulator. The shape of the case electrodes of this cell allows one doughnut shaped surface and the inner cylindrical case wall to be used as an electrode and a second planar doughnut shaped surface and the outer cylindrical case wall to be used as another electrode. Connectors may be used to stack two or more toroidal cells together by connecting the entire surface area of the electrode of one cell to the entire surface area of the electrode of a second cell. The central cavity of each toroidal cell may be used as a conduit for pumping a fluid through the toroidal cell to thereby cool the cell. NASA

N80-33889*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RADIATION DAMAGE IN HIGH VOLTAGE SILICON SOLAR CELLS
Irving Weinberg, Henry W. Brandhorst, Clifford K. Swartz, and Victor G. Weizer *In* ESA Photovoltaic Generators in Space Jun. 1980 p 129-134 refs (For primary document see N80-33873 24-44)
Avail: NTIS HC A12/MF A01; ESA, Paris FF 80 CSCL 10A

High open circuit voltage cell designs based on 0.1 Ohm cm p-type silicon were irradiated with 1 MeV electrons and their performance determined to fluences as high as 10 to the 15th power per sq cm. Of the three cell designs, radiation induced degradation was greatest in the high low emitter (HLE) cell. The diffused and ion implanted cells degraded approximately equally but less than the HLE cell. Degradation was greatest in an HLE cell exposed to X-rays before electron irradiation. The cell regions controlling both short circuit current and open circuit voltage degradation were defined in all three cell types. An increase in front surface recombination velocity accompanied time dependent degradation of an HLE cell after X-irradiation. It was speculated that this was indirectly due to a decrease in positive charge at the silicon oxide interface. Modifications aimed at reducing radiation induced degradation are proposed for all three cell types. Author (ESA)

A80-11972 * **Survey of MHD plant applications.** J. J. Lynch (U.S. Department of Energy, Washington, D.C.), G. R. Seikel (NASA, Lewis Research Center, Cleveland, Ohio), and J. C. Cutting (Gilbert/Commonwealth, Inc., Reading, Pa.). In: Energy technology VI: Achievements in perspective; Proceedings of the Sixth Conference, Washington, D.C., February 26-28, 1979. (A80-11953 02-44)

Washington, D.C., Government Institutes, Inc., 1979, p. 793-807. 24 refs.

Open-cycle MHD is one of the major R&D efforts in the Department of Energy's program to meet the national goal of reducing U.S. dependence on oil through increased utilization of coal. MHD offers an effective way to use coal to produce electric power at low cost in a highly efficient and environmentally acceptable manner. Open-cycle MHD plants are categorized by the MHD combustor oxidizer, its temperature and the method of preheat. The paper discusses MHD baseline plant design, open-cycle MHD plant in the Energy Conversion Alternatives Study (ECAS), early commercial MHD plants, conceptual studies of the engineering test facility, retrofit (addition of an MHD topping cycle to an existing steam plant), and other potential applications and concepts. Emphasis is placed on a survey of both completed and ongoing studies to define both commercial and pilot plant design, cost, and performance. S.D.

A80-28804 * # **Numerical calculation of steady inviscid full potential compressible flow about wind turbine blades.** D. S. Dulikravich (NASA, Lewis Research Center, Cleveland, Ohio). In: Wind Energy Conference, Boulder, Colo., April 9-11, 1980, Technical Papers. (A80-28801 10-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 14-19. 9 refs. Research sponsored by the National Research Council. (AIAA 80-0607)

The air flow through a propeller-type wind turbine rotor is characterized by three-dimensional rotating cascade effects about the inner portions of the rotor blades and compressibility effects about the tip regions of the blades. In the case of large rotor diameter and/or increased rotor angular speed, the existence of small supersonic zones terminated by weak shocks is possible. An exact nonlinear mathematical model (called a steady Full Potential Equation - FPE) that accounts for the above phenomena has been rederived. An artificially time dependent version of FPE was iteratively solved by a finite volume technique involving an artificial viscosity and a three-level consecutive mesh refinement. The exact boundary conditions were applied by generating a boundary conforming periodic computation mesh. (Author)

A80-28835 * # **Installation and checkout of the DOE/NASA Mod-1 2000-kW wind turbine generator.** R. L. Puthoff, J. L. Collins, and R. A. Wolf (NASA, Lewis Research Center, Cleveland, Ohio). In: Wind Energy Conference, Boulder, Colo., April 9-11, 1980, Technical Papers. (A80-28801 10-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 249-260. 5 refs. (AIAA 80-0638)

The paper describes the DOE/NASA Mod-1 wind turbine generator, its assembly and testing, and its installation at Boone, North Carolina. The paper concludes with performance data taken during the initial tests conducted on the machine. The successful installation and initial operation of the Mod-1 wind turbine generator has had the following results: (1) megawatt-size wind turbines can be operated satisfactorily on utility grids; (2) the structural loads can be predicted by existing codes; (3) assembly of the machine on top of the tower presents no major problem; (4) large blades 100 ft long can be transported long distances and over mountain roads; and (5) operating experience and performance data will contribute substantially to the design of future low-cost wind turbines. S.D.

A80-28836 * # **Teetered, tip-controlled rotor - Preliminary test results from Mod-O 100-kW experimental wind turbine.** J. C. Glasgow and D. R. Miller (NASA, Lewis Research Center, Cleveland, Ohio). In: Wind Energy Conference, Boulder, Colo., April 9-11, 1980, Technical Papers. (A80-28801 10-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 261-268. 5 refs. (AIAA 80-0642)

A series of tests is currently being conducted using the DOE/NASA 100 kW Experimental Wind Turbine with a two-bladed, teetered rotor with 30% span tip control. Preliminary evaluation test results indicates that the teetered rotor significantly decreases loads on the yaw drive mechanism and reduces blade cyclic flapwise bending moments by 25% at the 20% span location when compared to rigid hub rotor. The teetered hub performed well but did impact the teeter stops on occasion as wind speed and/or direction varied rapidly. The tip-controlled rotor performed satisfactorily with some expected loss of control when compared to the full span pitchable blade. The performance results indicate that a review of techniques used to calculate rotor power is in order. (Author)

A80-35730 * # **The use of wind data with an operational wind turbine in a research and development environment.** H. E. Neustadter (NASA, Lewis Research Center, Cleveland, Ohio). In: Conference and Workshop on Wind Energy Characteristics and Wind Energy Siting, Portland, Ore., June 19-21, 1979, Proceedings. (A80-35716 14-44) Boston, Mass., American Meteorological Society, 1979, p. 179-188; Discussion, p. 189. 9 refs.

It is noted that in 1976, 17 candidate sites were identified for detailed evaluation as potential sites for installation of large, horizontal axis Wind Turbines (WT). Attention is given to the Mod-OA, a 200 kW WT located in Clayton, New Mexico. The discussion covers the meteorological data collected, some of the analyses based on these wind data as well as additional areas currently being investigated in relation to these data. M.E.P.

A80-39639 * # **Improved PFB operations - 400-hour turbine test results.** R. J. Rollbuhler, S. M. Benford, and G. R. Zellars (NASA, Lewis Research Center, Cleveland, Ohio). *DOE, EPRI, EPA, and Tennessee Valley Authority, International Conference on Fluidized Bed Combustion, 6th, Atlanta, Ga., Apr. 9-11, 1980, Paper.* 21 p. 14 refs.

The paper deals with a 400-hr small turbine test in the effluent of a pressurized fluidized bed (PFB) at an average temperature of 770 C, an average relative gas velocity of 300 m/sec, and average solid loadings of 200 ppm. Consideration is given to combustion parameters and operating procedure as well as to the turbine system and turbine test operating procedures. Emphasis is placed on erosion/corrosion results. V.T.

A80-39642 * # **Comments on TEC trends.** J. F. Morris (NASA, Lewis Research Center, Cleveland, Ohio). *Institute of Electrical and Electronics Engineers, International Conference on Plasma Science, Montreal, Canada, June 4-6, 1979, Paper.* 26 p. 54 refs.

The paper comments on published and projected thermionic-energy-conversion (TEC) performance trends. This commentary includes graphs and an appendix relating TEC performance parameters, plots of predicted and actual TEC trends, a figure relating projected cost of electricity to overall efficiency for TEC topping, and a discussion of the implications of these relationships. V.T.

A80-40335 * # **Modified aerospace R&QA method for wind turbines.** W. E. Klein (NASA, Lewis Research Center, Cleveland, Ohio). In: Annual Reliability and Maintainability Symposium, San Francisco, Calif., January 22-24, 1980, Proceedings. (A80-40301 16-38) New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 254-258.

This paper describes the Safety, Reliability and Quality Assurance (SR&QA) approach developed for the first large wind turbine generator project, MOD-OA. The SR&QA approach to be used had to assure that the machine would not be hazardous, would operate unattended on a utility grid, would demonstrate reliable operation, and would help establish the quality assurance and maintainability requirements for wind turbine projects. The final approach consisted of a modified Failure Modes and Effects Analysis (FMEA) during the design phase, minimal hardware inspections during parts fabrication, and three documents to control activities during machine construction and operation. (Author)

A80-40338 * # **Photovoltaic power system reliability considerations.** V. R. Lalli (NASA, Lewis Research Center, Cleveland, Ohio). In: Annual Reliability and Maintainability Symposium, San Francisco, Calif., January 22-24, 1980, Proceedings. (A80-40301 16-38) New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 283-286.

This paper describes an example of how modern engineering and safety techniques can be used to assure the reliable and safe operation of photovoltaic power systems. This particular application was for a solar cell power system demonstration project in Tangaye, Upper Volta, Africa. The techniques involve a definition of the power system natural and operating environment, use of design criteria and analysis techniques, an awareness of potential problems via the inherent reliability and FMEA methods, and use of a fail-safe and planned spare parts engineering philosophy. (Author)

A80-45722 * # **Spectral effects on direct-insolation absorptance of five collector coatings.** G. B. Hotchkiss (Texas Instruments, Inc., Dallas, Tex.), F. F. Simon (NASA, Lewis Research Center, Cleveland, Ohio), and L. C. Burmeister (Kansas, University, Lawrence, Kan.). *American Society of Mechanical Engineers and American Institute of Chemical Engineers, Joint National Heat Transfer Conference, 18th, San Diego, Calif., Aug. 6-8, 1979, ASME Paper 79-HT-18.* 7 p. 16 refs. Members, $1.50; nonmembers, $3.00. Grant No. NsG-3087.

Absorptances for direct insolation of black chrome, black nickel, copper oxide, and two black zinc conversion selective coatings were calculated for a number of typical solar spectrums. Measured spectral reflectances were used while the effects of atmospheric ozone density, turbidity, and air mass were incorporated in calculated direct solar spectrums. Absorptance variation for direct insolation was found to be of the order of 1 percent for a typical range of clear-sky atmospheric conditions. (Author)

A80-46414 * # **Cycles till failure of silver-zinc cells with competing failure modes - Preliminary data analysis.** S. M. Sidik, H. F. Leibecki, and J. M. Bozek (NASA, Lewis Research Center, Cleveland, Ohio). *American Statistical Association, Annual Meeting, Houston, Tex., Aug. 11-14, 1980, Paper.* 46 p. 10 refs.

The data analysis of cycles to failure of silver-zinc electrochemical cells with competing failure modes is presented. The test ran 129 cells through charge-discharge cycles until failure; preliminary data analysis consisted of response surface estimate of life. Batteries fail through low voltage condition and an internal shorting condition; a competing failure modes analysis was made using maximum likelihood estimation for the extreme value life distribution. Extensive residual plotting and probability plotting were used to verify data quality and selection of model. A.T.

A80-46796 * **Description of photovoltaic village power systems in the United States and Africa.** A. F. Ratajczak and W. J. Bifano (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Solar Energy Conference, 2nd, Berlin, West Germany, April 23-26, 1979, Proceedings. (A80-46694 20-44) Dordrecht, D. Reidel Publishing Co., 1979, p. 1087-1095.

The paper describes the designs, hardware, and installations of NASA photovoltaic power systems in the village of Schuchuli in Arizona and Tangaye in Upper Volta, Africa. The projects were designed to demonstrate that current photovoltaic system technology can provide electrical power for domestic services for small, remote communities. The Schuchuli system has a 3.5 kW peak solar array which provides power for water pumping, a refrigerator for each family, lights, and community washing and sewing machines. The 1.8 kW Tangaye system provides power for pumping, flour milling, and lights in the milling building. Both are stand-alone systems operated by local personnel, and they are monitored by NASA to measure design adequacy and refine future designs. A.T.

A80-48194 * # **Energy conservation and environmental benefits of thermal energy storage systems in the pulp and paper industry.** H. Edde (Howard Edde, Inc., Bellevue, Wash.) and M. W. Dietrich (NASA, Lewis Research Center, Cleveland, Ohio). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 1. (A80-48165 21-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 239-242. 7 refs. Contract No. DEN3-190.

A80-48205 * # **The planar multijunction cell - A new solar cell for earth and space.** J. C. Evans, Jr., A.-T. Chai (NASA, Lewis Research Center, Cleveland, Ohio), and C. Goradia. In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 1. (A80-48165 21-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 358-363. 7 refs.

A new family of high-voltage solar cells, called the planar multijunction (PMJ) cell is being developed. The new cells combine the attractive features of planar cells with conventional or interdigitated back contacts and the vertical multijunction (VMJ) solar cell. The PMJ solar cell is internally divided into many voltage-generating regions, called unit cells, which are internally connected in series. The key to obtaining reasonable performance from this device was the separation of top surface field regions over each active unit cell area. Using existing solar cell fabricating methods, output voltages in excess of 20 volts per linear centimeter are possible. Analysis of the new device is complex, and numerous geometries are being studied which should provide substantial benefits in both normal sunlight usage as well as with concentrators. (Author)

A80-48329 * # **Effect of positive pulse charge waveforms on cycle life of nickel-zinc cells.** J. J. Smithrick (NASA, Lewis Research Center, Cleveland, Ohio). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 2. (A80-48165 21-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 1203-1206. 7 refs. Contract No. EC-77-A-31-1044.

Five amp-hour nickel-zinc cells were life cycled to evaluate four different charge methods. Three of the four waveforms investigated were 120 Hz full wave rectified sinusoidal (FWRS), 120 Hz silicon controlled rectified (SCR), and 1 kHz square wave (SW). The fourth, a constant current method, was used as a baseline of comparison. Three sealed Ni-Zn cells connected in series were cycled. Each series string was charged at an average c/20 rate, and discharged at a c/2.5 rate to a 75% rated depth. Results indicate that the relatively inexpensive 120 Hz FWRS charger appears feasible for charging 5 amp-hour nickel-zinc cells with no significant loss in average cycle life when compared to constant current charging. The 1-kHz SW charger could also be used with no significant loss in average cycle life, and suggests the possibility of utilizing the existing electric vehicle chopper controller circuitry for an on-board charger. There was an apparent difference using the 120 Hz SCR charger compared to the others, however, this difference could be due to an inadvertent severe overcharge, which occurred prior to cell failure. The remaining two positive pulse charging waveforms, FWRS and 1 kHz, did not improve the cycle life of 5 amp-hour nickel-zinc cells over that of constant current charging. (Author)

A80-48370 * # **Improvement and scale-up of the NASA Redox storage system.** M. A. Reid and L. H. Thaller (NASA, Lewis Research Center, Cleveland, Ohio). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 2. (A80-48165 21-44) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 1471-1476. 9 refs.

A preprototype full-function 1.0 kW Redox system (2 kW peak) with 11 kW storage capacity has been built and integrated with the

NASA/DOE photovoltaic test facility. The system includes four substacks of 39 cells each (1/3 sq ft active area) which are connected hydraulically in parallel and electrically in series. An open circuit voltage cell and a set of rebalance cells are used to continuously monitor the system state of charge and automatically maintain the anode and cathode reactants electrochemically in balance. Technological advances in membrane and electrodes and results of multicell stack tests are reviewed. V.L.

N80-10603*# Energy Research Corp., Danbury, Conn.
TECHNOLOGY DEVELOPMENT FOR PHOSPHORIC ACID FUEL CELL POWERPLANT, PHASE 2 Quarterly Report
Larry Christner Jun. 1979 72 p Prepared for DOE
(Contract DEN3-67)
(NASA-CR-159705; DOE/NASA/0067-79-2; QR-3) Avail: NTIS HC A04/MF A01 CSCL 10A

A technique for producing an acid inventory control member by spraying FEP onto a partially screened carbon paper backing is discussed. Theoretical analysis of the acid management indicates that the vapor composition of 103% H3PO4 is approximately 1.0 ppm P4O10. An SEM evaluation of corrosion resistance of phenolic resins and graphite/phenolic resin composites in H3PO4 at 185 C shows specific surface etching. Carbonization of graphite/phenolic bipolar plates is achieved without blistering. K.L.

N80-10622*# General Electric Co., Schenectady, N. Y.
CONCEPTUAL DESIGN OF THERMAL ENERGY STORAGE SYSTEMS FOR NEAR-TERM ELECTRIC UTILITY APPLICATIONS. VOLUME 2: APPENDIXES, SCREENING OF CONCEPTS
W. Hausz, B. J. Berkowitz, and R. C. Hare Apr. 1979 151 p refs
(Contract EC-77-A-31-1034; EPRI Proj. 1082-1)
(NASA-CR-159411; EPRI-EM-1037-Vol-2) Avail: NTIS HC A08/MF A01

Volume two contains three appendices entitled: (1) Bibliography and Cross References; (2) Taxonomy: Proponents and Sources; and (3) Concept Definitions. DOE

N80-11558*# General Electric Co., Philadelphia, Pa. Space Div.
EXECUTIVE SUMMARY: MOD-1 WIND TURBINE GENERATOR ANALYSIS AND DESIGN REPORT Final Report
Mar. 1979 61 p
(Contracts NAS3-20058; EC-77-A-29-1010)
(NASA-CR-159497; DOE/NASA/0058-79/3) Avail: NTIS HC A04/MF A01 CSCL 10A

Activities leading to the detail design of a wind turbine generator having a nominal rating of 1.8 megawatts are reported. Topics covered include (1) system description; (2) structural dynamics; (3) stability analysis; (4) mechanical subassemblies design; (5) power generation subsystem; and (6) control and instrumentation subsystem. A.R.H.

N80-11566*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
CHARACTERIZATION OF SOLAR CELLS FOR SPACE APPLICATIONS. VOLUME 10: ELECTRICAL CHARACTERISTICS OF SPECTROLAB BSF, TEXTURED, 10 OHM-CM, 300 MICRON CELLS AS A FUNCTION OF INTENSITY, TEMPERATURE AND IRRADIATION
B. E. Anspaugh, R. G. Downing, T. F. Miyahira, and R. S. Weiss 1 Oct. 1979 38 p
(Contract NAS7-100)
(NASA-CR-162422; JPL-Pub-78-15-Vol-10) Avail: NTIS HC A03/MF A01 CSCL 10A

Electrical characteristics of textured, back surface field, 10 ohm cm, 300 micron N/P silicon solar cells are presented in graphical and tabular format as a function of solar illumination intensity, and temperature. Author

N80-12551*# Ionics, Inc., Watertown, Mass. Research Div.
ANTON PERMSELECTIVE MEMBRANE
Samuel S. Alexander, Russell B. Hodgdon, and Warren A. Waite May 1979 52 p Sponsored by NASA
(Contract DEN3-1)
(NASA-CR-159599; DOE/NASA/0001-79/1) Avail: NTIS HC A04/MF A01 CSCL 10A

Experimental composite membranes were synthesized on a lab scale consisting of a thin layer of anion permselective resin supported by and bonded to a porous physically strong and conductive substrate film. These showed good selectivity and also substantially lower electrical resistivities than the homogenous candidate membranes optimized in the previous contract. A wide range of resin porosities were examined for three candidate membrane systems, CDIL, CP4L, and A3L to identify the formulation giving the best overall redox cell performance. Candidate anion membranes showed large increases in resistivity after a short time of immersion in concentrated FeCl/HCl solution. Largely on the basis of resistance stability the CDIL formulation was selected as prime candidate and about thirty-five membranes (one foot square) were produced for experimental static and dynamic evaluation. R.E.S.

N80-14490*# Power Electronics Associates, Inc., Lincoln, Mass.
BI-DIRECTIONAL FOUR QUADRANT (BDQ4) POWER CONVERTER DEVELOPMENT Final Report
Francis C. Schwarz 20 Dec. 1979 249 p refs
(Contract NAS3-30363)
(NASA-CR-159660) Avail: NTIS HC A11/MF A01 CSCL 10B

The feasibility for implementation of a concept for direct ac/dc multikilowatt power conversion with bidirectional transfer of energy was investigated. A 10 kHz current carrier was derived directly from a common 60 Hz three phase power system. This carrier was modulated to remove the 360 Hz ripple, inherent in the three phase power supply and then demodulated and processed by a high frequency filter. The resulting dc power was then supplied to a load. The process was implemented without the use of low frequency transformers and filters. This power conversion processes was reversible and can operate in the four quadrants as viewed from any of the two of the converter's ports. Areas of application include: power systems on air and spacecraft; terrestrial traction; integration of solar and wind powered systems with utility networks; HVDC; asynchronous coupling of polyphase networks; heat treatment; industrial machine drives; and power supplies for any use including instrumentation. R.C.T.

N80-15553*# Technical Report Services, Rocky River, Ohio.
EVALUATION OF FEASIBILITY OF PRESTRESSED CONCRETE FOR USE IN WIND TURBINE BLADES
Seymour Leiblein, D. S. Londahl, Donn B. Furlong, and Mark E. Dreier Sep. 1979 119 p refs Prepared in cooperation with Tuthill Pump Co., San Rafael, Calif. and Paragon Pacific, Inc., El Segundo, Calif.
(Contracts NAS3-20596; NAS3-30813; EX-76-I-01-1028; NASA Order C-25906)
(NASA-CR-159725; DOE/NASA/5906-79/1) Avail: NTIS HC A06/MF A01 CSCL 10B

A preliminary evaluation of the feasibility of the use of prestressed concrete as a material for low cost blades for wind turbines was conducted. A baseline blade design was achieved for an experimental wind turbine that met aerodynamic and structural requirements. Significant cost reductions were indicated for volume production. Casting of a model blade section showed no fabrication problems. Coupled dynamic analysis revealed that adverse rotor tower interactions can be significant with heavy rotor blades. R.C.T.

N80-15559*# Solarex Corp., Rockville, Md.
ECONOMICAL SPACE POWER SYSTEMS
Joel H. Burkholder Jan. 1980 161 p refs
(Contract NAS3-21353)
(NASA-CR-159696) Avail: NTIS HC A08/MF A01 CSCL 10B

A commercial approach to design and fabrication of an economical space power system is investigated. Cost projections are based on a 2 kW space power system conceptual design taking into consideration the capability for serviceability, constraints of operation in space, and commercial production engineering approaches. A breakdown of the system design, documentation, fabrication, and reliability and quality assurance estimated costs are detailed. M.G.

N80-16483*# Energy Technology, Inc., Cleveland, Ohio
STUDY OF ADVANCED RADIAL OUTFLOW TURBINE FOR SOLAR STEAM RANKINE ENGINES
Cecil Martin and Terry Kolenc Dec. 1979 74 p refs
(Contract DEN3-86)
(NASA-CR-159695; DOE/NASA/0086-79/1; ETI-1279) Avail: NTIS HC A04/MF A01 CSCL 10B

The performance characteristics of various steam Rankine engine configurations for solar electric power generation were investigated. A radial outflow steam turbine was investigated to determine: (1) a method for predicting performance from experimental data, (2) the flexibility of a single design with regard to power output and pressure ratio, and (3) the effect of varying the number of turbine stages. All turbine designs were restricted to be compatible with commercially available gearboxes and generators. A study of several operating methods and control schemes for the steam Rankine engine shows that from an efficiency and control simplicity standpoint, the best approach is to hold turbine inlet temperature constant, vary turbine inlet pressure to match load, and allow condenser temperature to float maintaining constant heat rejection load. A.R.H.

N80-16491*# Foster-Miller Associates, Inc., Waltham, Mass.
A 15kWe (NOMINAL) SOLAR THERMAL ELECTRIC POWER CONVERSION CONCEPT DEFINITION STUDY: STEAM RANKINE REHEAT RECIPROCATOR SYSTEM Final Report
H. Fuller, R. Demler, E. Poulin, and P. Dantowitz Jun. 1979 63 p refs
(Contracts DEN3-62; EX-76-A-29-1060)
(NASA-CR-159590; DOE/NASA/0062-79/1; NAS-7845) Avail: NTIS HC A04/MF A01 CSCL 10B

An evaluation was made of the potential of a steam Rankine reheat reciprocator engine to operate at high efficiency in a point-focusing distributed receiver solar thermal-electric power system. The scope of the study included the engine system and electric generator; not included was the solar collector/mirror or the steam generator/receiver. A parametric analysis of steam conditions was completed leading to the selection of 973 K 12.1 MPa as the steam temperature/pressure for a conceptual design. A conceptual design was completed for a two cylinder/opposed engine operating at 1800 rpm directly coupled to a commercially available induction generator. A unique part of the expander design is the use of carbon/graphite piston rings to eliminate the need for using oil as an upper cylinder lubricant. The evaluation included a system weight estimate of 230 kg at the mirror focal point with the condenser mounted separately on the ground. The estimated cost of the overall system is $1932 or $90/kW for the maximum 26 kW output. R.E.S.

N80-16493*# Sundstrand Corp., Rockford, Ill.
THE 15 kW SUB e (NOMINAL) SOLAR THERMAL ELECTRIC POWER CONVERSION CONCEPT DEFINITION STUDY: STEAM RANKINE TURBINE SYSTEM Final Report
Timothy J. Bland Oct. 1979 63 p refs
(Contracts DEN3-61; EX-76-A-29-1060)
(NASA-CR-159589; AER-1713; DOE/NASA/0061-79/1) Avail: NTIS HC A04/MF A01 CSCL 10A

A study to define the performance and cost characteristics of a solar powered, steam Rankine turbine system located at the focal point of a solar concentrator is presented. A two stage re-entry turbine with reheat between stages, which has an efficiency of 27% at a turbine inlet temperature of 732 C was used. System efficiency was defined as 60 Hertz electrical output divided by absorbed thermal input in the working fluid. Mass production costs were found to be approximately 364 dollars/KW. R.E.S.

N80-17543*# Electro-Mechanical Research, Inc. Sarasota, Fla.
DOE/NASA WIND TURBINE DATA ACQUISITION. PART 1: EQUIPMENT
O. J. Strock Jan. 1980 56 p
(Contract DEN3-98)
(NASA-CR-159779; EMR-827053) Avail: NTIS HC A04/MF A01 CSCL 10B

Large quantities of data were collected, stored, and analyzed in connection with research and development programs on wind turbines. The hardware configuration of the wind energy remote data acquisition system is described along with its use on the NASA/DOE Wind Energy Program. R.C.T.

N80-17547*# Institute of Gas Technology, Chicago, Ill.
HIGH-TEMPERATURE MOLTEN SALT THERMAL ENERGY STORAGE SYSTEMS Final Report, 14 Sep. 1977 - 14 Dec. 1978
Randy J. Petri, Terry D. Claar, Ray R. Tison, and Leonard G. Marianowski Feb. 1980 175 p refs
(Contract NAS3-20806)
(NASA-CR-159663; DOE/NASA/0806-79/1) Avail: NTIS HC A08/MF A01 CSCL 10A

The results of comparative screening studies of candidate molten carbonate salts as phase change materials (PCM) for advanced solar thermal energy storage applications at 540 to 870 C (1004 to 1600 F) and steam Rankine electric generation at 400 to 540 C (752 to 1004 F) are presented. Alkali carbonates are attractive as latent heat storage materials because of their relatively high storage capacity and thermal conductivity, low corrosivity, moderate cost, and safe and simple handling requirements. Salts were tested in 0.1 kWhr lab scale modules and evaluated on the basis of discharge heat flux, solidification temperature range, thermal cycling stability, and compatibility with containment materials. The feasibility of using a distributed network of high conductivity material to increase the heat flux through the layer of solidified salt was evaluated. The thermal performance of an 8 kWhr thermal energy storage (TES) module containing $LiKCO_3$ remained very stable throughout 5650 hours and 130 charge/discharge cycles at 480 to 535 C (896 to 995 F). A TES utilization concept of an electrical generation peaking subsystem composed of a multistage condensing steam turbine and a TES subsystem with a separate power conversion loop was defined. Conceptual designs for a 100 MW sub e TES peaking system providing steam at 316 C, 427 C, and 454 C (600 F, 800 F, and 850 F) at 3.79 million Pa (550 psia) were developed and evaluated. Areas requiring further investigation have also been identified. Author

N80-17548*# Kaman Aerospace Corp., Bloomfield, Conn.
DESIGN, FABRICATION, TEST, AND EVALUATION OF A PROTOTYPE 150-FOOT LONG COMPOSITE WIND TURBINE BLADE Final Report
Herbert W. Gewehr Sep. 1979 135 p refs
(Contracts NAS3-20600; EX-76-I-01-1028)
(NASA-CR-159775; DOE/NASA/0600-79/1; R-1575) Avail: NTIS HC A07/MF A01 CSCL 10B

The design, fabrication, testing, and evaluation of a prototype 150 foot long composite wind turbine blade is described. The design approach and material selection, compatible with low cost fabrication methods and objectives, are highlighted. The operating characteristics of the blade during rotating and nonrotating conditions are presented. The tensile, compression, and shear properties of the blade are reported. The blade fabrication, tooling, and quality assurance are discussed. A.W.H.

N80-18554*# Spectrolab, Inc., Sylmar, Calif.
DEVELOPMENT OF IMPROVED WRAPAROUND CONTACTS FOR SILICON Final Report
Jay W. Thornhill Dec. 1979 41 p
(Contract NAS3-20065)
(NASA-CR-159748) Avail: NTIS HC A03/MF A01 CSCL 10A

A developmental process for fabricating 2 X 4 cm back surface field silicon solar cells featuring wraparound contacts and screen printed dielectric isolation is described. The process was then used to fabricate a number of cells for evaluation and study, as well as to establish the validity of the process sequence. While a number of cells exhibiting relatively good conversion efficiencies were produced, nearly all had low I-V curve factors for the level of efficiencies attained. Cells with conversion efficiencies of more than 15 percent (air mass zero and 25 C) had fill factors of only 0.76. Evidence as to the cause of this has not been conclusive, but is most probably linked to isolation failure in the wraparound dielectric and associated shunting problems. Author

N80-18559*# Avco Corp., Wilmington, Mass.
PARAMETRIC STUDY OF POTENTIAL EARLY COMMERCIAL MHD POWER PLANTS Final Report
Finn A. Hals Dec. 1979 246 p refs
(Contracts DEN3-51; EF-77-A-01-2674)
(NASA-CR-159633; DOE/NASA/0051-79/1) Avail: NTIS HC A11/MF A01 CSCL 10B

Three different reference power plant configurations were considered with parametric variations of the various design parameters for each plant. Two of the reference plant designs were based on the use of high temperature regenerative air preheaters separately fired by a low Btu gas produced from a coal gasifier which was integrated with the power plant. The third reference plant design was based on the use of oxygen enriched combustion air preheated to a more moderate temperature in a tubular type metallic recuperative heat exchanger which is part of the bottoming plant heat recovery system. Comparative information was developed on plant performance and economics. The highest net plant efficiency of about 45 percent was attained by the reference plant design with the use of a high temperature air preheater separately fired with the advanced entrained bed gasifier. The use of oxygen enrichment of the combustion air yielded the lowest cost of generating electricity at a slightly lower plant efficiency. Both of these two reference plant designs are identified as potentially attractive for early MHD power plant applications. R.E.S.

N80-18562*# Grumman Aerospace Corp., Bethpage, N.Y.
ACTIVE HEAT EXCHANGE SYSTEM DEVELOPMENT FOR LATENT HEAT THERMAL ENERGY STORAGE Topical Report, Jun. 1978 - Feb. 1979
Joseph Alario, Robert Kosson, and Robert Haslett Jan. 1980 73 p refs
(Contracts DEN3-39; EC-77-A-31-1034)
(NASA-CR-159726; DOE/NASA/0039-79/1; GAC-TR-1681-09) Avail: NTIS HC A04/MF A01 CSCL 10A

Various active heat exchange concepts were identified from among three generic categories: scrapers, agitators/vibrators and slurries. The more practical ones were given a more detailed technical evaluation and an economic comparison with a passive tube-shell design for a reference application (300 MW sub t storage for 6 hours). Two concepts were selected for hardware development: (1) a direct contact heat exchanger in which molten salt droplets are injected into a cooler counterflowing stream of liquid metal carrier fluid, and (2) a rotating drum scraper in which molten salt is sprayed onto the circumference of a rotating drum, which contains the fluid salt is sprayed onto the circumference of a rotating drum, which contains the fluid heat sink in an internal annulus near the surface. A fixed scraper blade removes the solidified salt from the surface which was nickel plated to decrease adhesion forces. In addition to improving performance by providing a nearly constant transfer rate during discharge, these active heat exchanger concepts were estimated to cost at least 25% less than the passive tube-shell design. R.E.S.

N80-18565*# General Electric Co., Philadelphia, Pa. Space Div.
APPENDIX: MOD-1 WIND TURBINE GENERATOR ANALYSIS AND DESIGN REPORT, VOLUME 2 Final Report
May 1979 425 p
(Contracts NAS3-20058; EX-77-A-29-1010)
(NASA-CR-159496; DOE/NASA/0058-79/2-Vol-2-App) Avail: NTIS HC A18/MF A01 CSCL 10B

The MOD-1 detail design is appended. The supporting analyses presented include a parametric system trade study, a verification of the computer codes used for rotor loads analysis, a metal blade study, and a definition of the design loads at each principal wind turbine generator interface for critical loading conditions. Shipping and assembly requirements, composite blade development, and electrical stability are also discussed. K.L.

N80-19612*# Jay - Carter Enterprises, Inc., Burkburnett, Tex.
A 15 kWe (NOMINAL) SOLAR THERMAL-ELECTRIC POWER CONVERSION CONCEPT DEFINITION STUDY: STEAM RANKIN RECIPROCATOR SYSTEM Final Report
W. Wingenback and J. Carter, Jr. Jun. 1979 46 p refs
(Contracts DEN3-63; EX-76-A-29-1060)
(NASA-CR-159591; DOE/NASA/0063-79/1) Avail: NTIS HC A03/MF A01 CSCL 10A

A conceptual design of a 3600 rpm reciprocation expander was developed for maximum thermal input power of 80 kW. The conceptual design covered two engine configurations; a single cylinder design for simple cycle operation and a two cylinder design for reheat cycle operation. The reheat expander contains a high pressure cylinder and a low pressure cylinder with steam being reheated to the initial inlet temperature after expansion in the high pressure cylinder. Power generation is accomplished with a three-phase induction motor coupled directly to the expander and connected electrically to the public utility power grid. The expander, generator, water pump and control system weigh 297 kg and are dish mounted. The steam condenser, water tank and accessory pumps are ground based. Maximum heat engine efficiency is 33 percent: maximum power conversion efficiency is 30 percent. Total cost is $3,307 or $138 per kW of maximum output power. R.E.S.

N80-19615*# United Technologies Corp., South Windsor, Conn. Power Systems Div.
ADVANCED TECHNOLOGY LIGHT WEIGHT FUEL CELL PROGRAM Final Report, 28 Jul. 1978 - 28 Jul. 1979
R. E. Martin 1979 52 p refs
(Contract NAS3-21257)
(NASA-CR-159807; FCR-1657) Avail: NTIS HC A04/MF A01 CSCL 10B

The development of a long life, high performance, high efficiency, hydrogen oxygen alkaline fuel cell configuration for application to a NASA orbiting space vehicle is documented. Seven full-size 0.25 ft 2 active area single cells were constructed and tested at cell temperatures between 140 F and 200 F, current densities out to 500 ASF, and reactant pressures up to 30 psia. Cells incorporating platinum-supported-on-carbon catalyst anodes demonstrated 8,085 cell-hours of endurance operation with virtually no change in performance and 2,995 cell-hours of operation to a cyclical load profiles with no apparent loss in cathode performance due to high voltage operation. Cell edge frame materials and heat treated polybenzimidazole (PBI) matrix samples were corrosion tested in 42 wt % aqueous potassium hydroxide at 250 F. Based upon available test data, PBI appears unsuitable for use as a fuel cell matrix material. Five semiconducting oxides were evaluated as cathode catalysts and as cathode catalyst supports. The candidate supports LaMnO3 and LaNiO3 appear to have development potential and merit further study. K.L.

N80-19632*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ANNUAL TECHNICAL REPORT, FISCAL YEAR 1979. VOLUME 1: EXECUTIVE SUMMARY Annual Report
John W. Lucas 15 Jan. 1980 46 p Sponsored in part by DOE
(Contract NAS7-100)
(NASA-CR-159715; JPL-Pub-79-112-Vol-1) Avail: NTIS HC A03/MF A01 CSCL 10A

Accomplishments of the Point-Focusing Distributed Receiver Technology project are presented. The following aspects of the project are discussed: information dissemination, concentrator development, receiver and heat transport network development, power conversion, manufacturing, systems engineering, and tests and evaluations R.E.S.

N80-20864*# General Electric Co., Philadelphia, Pa. Space Div.

MOD 1 WIND TURBINE GENERATOR FAILURE MODES AND EFFECTS ANALYSIS

Feb. 1979 95 p

(Contracts NAS3-20058; EX-77-A-29-1010)

(NASA-CR-159494; DOE/NASA/0058-79/1) Avail: NTIS HC A05/MF A01 CSCL 10B

A failure modes and effects analysis (FMEA) was directed primarily at identifying those critical failure modes that would be hazardous to life or would result in major damage to the system. Each subsystem was approached from the top down, and broken down to successive lower levels where it appeared that the criticality of the failure mode warranted more detail analysis. The results were reviewed by specialists from outside the Mod 1 program, and corrective action taken wherever recommended. A.R.H.

N80-22775*# Spire Corp., Bedford, Mass.

STUDY PROGRAM TO IMPROVE THE OPEN-CIRCUIT VOLTAGE OF LOW RESISTIVITY SINGLE CRYSTAL SILICON SOLAR CELLS

J. A. Minnucci and K. W. Matthei 7 Feb. 1980 119 p refs

(Contract NAS3-20823)

(NASA-CR-159833; FR-10056) Avail: NTIS HC A06/MF A01 CSCL 10A

The results of a 14 month program to improve the open circuit voltage of low resistivity silicon solar cells are described. The approach was based on ion implantation in 0.1- to 10.0-ohm-cm float-zone silicon. As a result of the contract effort, open circuit voltages as high as 645 mV (AMO 25 C) were attained by high dose phosphorus implantation followed by furnace annealing and simultaneous SiO2 growth. One key element was to investigate the effects of bandgap narrowing caused by high doping concentrations in the junction layer. Considerable effort was applied to optimization of implant parameters, selection of furnace annealing techniques, and utilization of pulsed electron beam annealing to minimize thermal process-induced defects in the completed solar cells. F.O.S.

N80-22778*# AiResearch Mfg. Co., Phoenix, Ariz.

CONCEPT DEFINITION STUDY OF SMALL BRAYTON CYCLE ENGINES FOR DISPERSED SOLAR ELECTRIC POWER SYSTEMS Final Report, Sep. 1978 - Jun. 1979

Lyle D. Six, Thomas L. Ashe, Frank X. Dobler, and Ron T. Elkins Jan. 1980 135 p refs

(Contracts DEN3-69; EX-76-A-29-1060)

(NASA-CR-159592; DOE/NASA/0069-79/1; AiResearch-31-3328) Avail: NTIS HC A07/MF A01 CSCL 10B

Three first-generation Brayton cycle engine types were studied for solar application: a near-term open cycle (configuration A), a near-term closed cycle (configuration B), and a longer-term open cycle (configuration C). A parametric performance analysis was carried out to select engine designs for the three configurations. The interface requirements for the Brayton cycle engine/generator and solar receivers were determined. A technology assessment was then carried out to define production costs, durability, and growth potential for the selected engine types. R.E.S.

N80-22787*# Mechanical Technology, Inc., Latham, N. Y. Stirling Engine Systems Div.

DESIGN STUDY OF A 15 kW FREE-PISTON STIRLING ENGINE-LINEAR ALTERNATOR FOR DISPERSED SOLAR ELECTRIC POWER SYSTEMS Final Report, Sep. 1978 - Aug. 1979

George R. Dochat, H. S. Chen, S. Bhate, and T. Marusak Aug. 1979 189 p refs

(Contracts DEN3-56; EX-76-A-29-1060)

(NASA-CR-159587; DOE/NASA/0056-79/1; MTI-79TR47) Avail: NTIS HC A08/MF A01 CSCL 10B

A conceptual design of a free piston solar Stirling engine-linear alternator which can be designed and developed to meet the requirements of a near-term solar test bed engine with minimum risks was developed. The conceptual design was calculated to have an overall system efficiency of 38% and provide 15kW electric output. The free piston engine design incorporates features such as gas bearings, close clearance seals, and gas springs. This design is hermetically sealed to provide long life, reliability, and maintenance free operation. An implementation assessment study performed indicates that the free piston solar Stirling engine-linear alternator can be manufactured at a reasonable price cost (direct labor plus material) of $2,500 per engine in production quantities of 25,000 units per year. Opportunity for significant reduction of cost was also identified. R.E.S.

N80-23768*# Westinghouse Research and Development Center, Pittsburgh, Pa.

CELL MODULE AND FUEL CONDITIONER DEVELOPMENT

D. Q. Hoover, Jr. Jan. 1980 58 p

(Contracts DEN3-161; DE-AI03-79ET-1272)

(NASA-CR-159828; DOE/NASA/0161-79/3; QR-1; Rept-80-9E6-MAREQ-R1) Avail: NTIS HC A04/MF A01

Components for the first 5 cell stack (no cooling plates) of the MK-2 design were fabricated. Preliminary specfications and designs for the components of a 23 cell MK-1 stack with four DIGAS cooling plates were developed. The MK-2 was selected as a bench mark design and a preliminary design of the facilities required for high rate manufacture of fuel cell modules was developed. Two stands for testing 5 cell stacks were built and design work for modifying existing stands and building new stands for 23 and 80 cell stacks was initiated. Design and procurement of components and materials for the catalyst test stand were completed and construction initiated. Work on the specifications of pipeline gas, tap water and recovered water and definition of equipment required for treatment was initiated. An innovative geometry for the reformer was conceived and modifications of the computer program to be used in its design were stated. R.E.S.

N80-23775*# General Electric Co., Philadelphia, Pa. Space Div.

MOD-1 WIND TURBINE GENERATOR ANALYSIS AND DESIGN REPORT, VOLUME 1 Final Report

Mar. 1979 320 p

(Contracts NAS3-20058; EX-77-A-29-1010)

(NASA-CR-159495; DOE/NASA/0058-79/2-Vol-1) Avail: NTIS HC A14/MF A01 CSCL 10A

The activities leading to the completion of detail design of the MOD-1 wind turbine generator are described. Emphasis is placed on the description of the design as it finally evolved. However, the steps through which the design progressed are also traced in order to understand the major design decisions. R.E.S.

N80-23842*# General Electric Co., Schenectady, N. Y.

CONCEPTUAL DESIGN OF THERMAL ENERGY STORAGE SYSTEMS FOR NEAR-TERM ELECTRIC UTILITY APPLICATIONS Final Report

E. W. Hall, W. Hausz, R. Anand, N. LaMarche, J. Oplinger, and M. Katzer Nov. 1979 524 p refs Sponsored by NASA and EPRI

(Contract EC-77-A-31-1034; EPRI Proj. 1082-1)

(NASA-CR-159577; EPRI-EM-1218) Avail: NTIS HC A22/MF A01 CSCL 10A

Over forty concepts were examined for storage media, forms of containment, and cycle configurations for conversion to electricity. An extensive analysis and screening process resulted in selecting two coal-fired and two nuclear plants for detail conceptual design. The coal plants utilized peaking turbines and the nuclear plants varied the feedwater extraction to change power output. It was shown that the performance and costs of even the best of these systems could not compete in near-term utility applications with cycling coal plants and typical gas turbines available for peaking power. Lower electricity costs, greater flexibility of operation, and other benefits can be provided by cycling coal plants for greater than 1500 hours of peaking or by gas turbines for less than 1500 hours if oil is available and its cost does not increase significantly. DOE

N80-24742*# PRC Systems Services Co., Huntsville, Ala.
SOLAR ARRAY SUBSYSTEMS STUDY Final Report, Mar. 1979 - May 1980
P. W. Richardson, F. Q. Miller, and M. B. Badgley 6 Jun. 1980 284 p
(Contract NAS3-21926)
(NASA-CR-159857) Avail: NTIS HC A13/MF A01 CSCL 10A

The effects on life cycle costs of a number of technology areas are examined for a LEO, 500 kW solar array. A baseline system conceptual design is developed and the life cycle costs estimated in detail. The baseline system requirements and design technologies are then varied and their relationships to life cycle costs quantified. For example, the thermal characteristics of the baseline design are determined by the array materials and masses. The thermal characteristics in turn determine configuration, performance and hence life cycle cost. Author

N80-24748*# Engelhard Minerals and Chemicals Corp., Edison, N. J.
DURABILITY TESTING AT 5 ATMOSPHERES OF ADVANCED CATALYSTS AND CATALYST SUPPORTS FOR GAS TURBINE ENGINE COMBUSTORS Final Report
B. A. Olson, H. C. Lee, I. T. Osgerby, R. M. Heck, and H. Hess Apr. 1980 95 p refs
(Contracts NAS3-19416; Contract EF-77-A-01-2593)
(NASA-CR-159839; DOE/NASA/9416-80/2) Avail: NTIS HC A05/MF A01 CSCL 10A

The durability of CATCOM catalysts and catalyst supports was experimentally demonstrated in a combustion environment under simulated gas turbine engine combustor operating conditions. A test of 1000 hours duration was completed with one catalyst using no. 2 diesel fuel and operating at catalytically-supported thermal combustion conditions. The performance of the catalyst was determined by monitoring emissions throughout the test, and by examining the physical condition of the catalyst core at the conclusion of the test. Tests were performed periodically to determine changes in catalytic activity of the catalyst core. Detailed parametric studies were also run at the beginning and end of the durability test, using no. 2 fuel oil. Initial and final emissions for the 1000 hours test respectively were: unburned hydrocarbons (C3 vppm):0, 146, carbon monoxide (vppm):30, 2420; nitrogen oxides (vppm):5.7, 5.6. R.E.S.

N80-24751*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLAR THERMAL POWER SYSTEMS POINT-FOCUSING DISTRIBUTED RECEIVER TECHNOLOGY PROJECT. VOLUME 2: DETAILED REPORT Annual Technical Report, fiscal year 1979
1 Apr. 1980 134 p refs Prepared in part by NASA. Lewis Res. Center, Cleveland, Ohio 2 Vol.
(Contracts NAS7-100; DE-AI01-79ET-20307; JPL Proj. 5104-61)
(NASA-CR-159715; DOE/JPL-1060-30-Vol-2; JPL-Pub-79-112-Vol-2) Avail: NTIS HC A07/MF A01 CSCL 10A

The accomplishments of the Point-Focusing Distributed Receiver Technology Project during fiscal year 1979 are detailed. Present studies involve designs of modular units that collect and concentrate solar energy via highly reflective, parabolic-shaped dishes. The concentrated energy is then converted to heat in a working fluid, such as hot gas. In modules designed to produce heat for industrial applications, a flexible line conveys the heated fluid from the module to a heat transfer network. In modules designed to produce electricity the fluid carries the heat directly to an engine in a power conversion unit located at the focus of the concentrator. The engine is mechanically linked to an electric generator. A Brayton-cycle engine is currently being developed as the most promising electrical energy converter to meet near-future needs. R.E.S.

N80-24758*# Boeing Engineering and Construction, Seattle, Wash.
MOD-2 WIND TURBINE SYSTEM CONCEPT AND PRELIMINARY DESIGN REPORT. VOLUME 1: EXECUTIVE SUMMARY
Jul. 1979 31 p
(Contracts DEN3-2; DE-AI01-793T-20305)
(NASA-CR-159609; DOE/NASA/0002-80/2) Avail: NTIS HC A03/MF A01 CSCL 10A

The configuration development of the MOD-2 wind turbine system is presented. The MOD-2 is design optimized for commercial production rates which, in multi-unit installations, will be integrated into a utility power grid and achieve a cost of electricity at less than 4 cents per kilowatt hour. R.E.S.

N80-24759*# Delaware Univ., Newark. Dept. of Chemical Engineering.
HEAT STORAGE IN ALLOY TRANSFORMATIONS
C. Ernest Birchenall Apr. 1980 29 p refs
(Grant NsG-3184; Contract EC-77-A-31-1034)
(NASA-CR-159787; DOE/NASA/3184-1) Avail: NTIS HC A03/MF A01 CSCL 10C

The feasibility of using metal alloys as thermal energy storage media was investigated. The elements selected as candidate media were limited to aluminum, copper, magnesium, silicon, zinc, calcium, and phosphorus on the basis of low cost and latent heat of transformation. Several new eutectic alloys and ternary intermetallic phases were determined. A new method employing X-ray absorption techniques was developed to determine the coefficients of thermal expansion of both the solid and liquid phases and the volume change during phase transformation. The method and apparatus are discussed and the experimental results are presented for aluminum and two aluminum-eutectic alloys. Candidate materials were evaluated to determine suitable materials for containment of the metal alloys. Graphite was used to contain the alloys during the volume change measurements. Silicon carbide was identified as a promising containment material and surface-coated iron alloys were also evaluated. System considerations that are pertinent if alloy eutectics are used as thermal energy storage media are discussed. Potential applications to solar receivers and industrial furnaces are illustrated schematically. R.E.S.

N80-24797*# General Electric Co., Schenectady, N. Y. Energy Technology Operation.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 1: SUMMARY REPORT Final Report
H. E. Gerlaugh, E. W. Hall, D. H. Brown, R. R. Priestley, and W. F. Knightly Jan. 1980 154 p
(Contract DEN3-31)
(NASA-CR-159765; GE79ET0102; DOE/NASA/0031-80/1) Avail: NTIS HC A08/MF A01 CSCL 10B

Large savings can be made in industry by cogenerating electric power and process heat in single energy conversion systems rather than separately in utility plants and in process boilers. About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidates which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed-cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum-based residual and distillate liquid fuels, and low Btu gas obtained through the on-site gasification of coal. An attempt was made to use consistent assumptions and a consistent set of ground rules for determining performance and cost in individual plants and on a national level. It was found that: (1) atmospheric and pressurized fluidized bed steam turbine systems were the most attractive of the direct coal-fired systems; and (2) open-cycle gas turbines with heat recovery steam generators and combined-cycles with NO(x) emission reduction and moderately increased firing temperatures were the most attractive of the coal-derived liquid-fired systems. R.E.S.

N80-25792*# United Technologies Corp., South Windsor, Conn. Power System Div.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY. VOLUME 1: SUMMARY REPORT Final Report
Jan. 1980 125 p
(Contracts DEN3-30; EC-77-A-31-1062)
(NASA-CR-159759; DOE/NASA/0030-80/1;
UTC-FCR-1333-Vol-1) Avail: NTIS HC A06/MF A01 CSCL 10A

Data and information in the area of advanced energy conversion systems for industrial congeneration applications in the 1985-2000 time period was studied. Six current and thirty-one advanced energy conversion systems were defined and combined with appropriate balance-of-plant equipment. Twenty-six industrial processes were selected from among the high energy consuming industries to serve as a framework for the study. Each conversion system was analyzed as a cogenerator with each industrial plant. Fuel consumption, costs, and environmental intrusion were evaluated and compared to corresponding traditional values. Various cogeneration strategies were analyzed and both topping and bottoming (using industrial by-product heat) applications were included. The advanced energy conversion technologies indicated reduced fuel consumption, costs, and emissions. Typically fuel energy savings of 10 to 25 percent were predicted compared to traditional on-site furnaces and utility electricity. With the variety of industrial requirements, each advanced technology had attractive applications. Overall, fuel cells indicated the greatest fuel energy savings and emission reductions. Gas turbines and combined cycles indicated high overall annual cost savings. Steam turbines and gas turbines produced high estimated returns. In some applications, diesels were most efficient. The advanced technologies used coal-derived fuels, or coal with advanced fluid bed combustion or on-site gasification systems. R.E.S.

N80-25793*# United Technologies Corp., South Windsor, Conn. Power Systems Div.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY. VOLUME 2: INDUSTRIAL PROCESS CHARACTERISTICS Final Report
Jan. 1980 697 p refs
(Contracts DEN3-30; EC-77-A-31-1062)
(NASA-CR-159760; DOE/NASA/0030-80/2;
UTC-FCR-1333-Vol-2) Avail: NTIS HC A99/MF A01 CSCL 10A

Information and data for 26 industrial processes are presented. The following information is given for each process: (1) a description of the process including the annual energy consumption and product production and plant capacity; (2) the energy requirements of the process for each unit of production and the detailed data concerning electrical energy requirements and also hot water, steam, and direct fired thermal requirements; (3) anticipated trends affecting energy requirements with new process or production technologies; and (4) representative plant data including capacity and projected requirements through the year 2000. R.E.S.

N80-25794*# United Technologies Corp., South Windsor, Conn. Power Systems Div.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY. VOLUME 4: HEAT SOURCES, BALANCE OF PLANT AND AUXILIARY SYSTEMS Final Report
Jan. 1980 296 p
(Contracts DEN3-30; EC-77-A-31-1062)
(NASA-CR-159762; DOE/NASA/0030-80/4;
UTC-FCR-1333-Vol-4) Avail: NTIS HC A13/MF A01 CSCL 10A

Data and information established for heat sources balance of plant items, thermal energy storage, and heat pumps are presented. Design case descriptions are given along with projected performance values. Capital cost estimates for representative cogeneration plants are also presented. R.E.S.

N80-25795*# United Technologies Corp., South Windsor, Conn. Power Systems Div.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY. VOLUME 6: COMPUTER DATA Final Report
Jan. 1980 535 p
(Contracts DEN3-30; EC-77-A-31-1062)
(NASA-CR-159764; DOE/NASA/0030-80/6;
UTC-FCR-1333-Vol-6) Avail: NTIS HC A22/MF A01 CSCL 10A

The potential technical capabilities of energy conversion systems in the 1985 - 2000 time period were defined with emphasis on systems using coal, coal-derived fuels or alternate fuels. Industrial process data developed for the large energy consuming industries serve as a framework for the cogeneration applications. Ground rules for the study were established and other necessary equipment (balance-of-plant) was defined. This combination of technical information, energy conversion system data ground rules, industrial process information and balance-of-plant characteristics was analyzed to evaluate energy consumption, capital and operating costs and emissions. Data in the form of computer printouts developed for 3000 energy conversion system-industrial process combinations are presented. R.E.S.

N80-26774*# Toledo Univ., Ohio.
NONLINEAR AEROELASTIC EQUATIONS OF MOTION OF TWISTED, NONUNIFORM, FLEXIBLE HORIZONTAL-AXIS WIND TURBINE BLADES Final Report
Krishna Rao V. Kaza Jul. 1980 70 p refs
(Grant NsG-3139; Contract EX-76-I-01-1028)
(NASA-CR-159502; DOE/NASA/3139-1) Avail: NTIS HC A04/MF A01 CSCL 10A

The second-degree nonlinear equations of motion for a flexible, twisted, nonuniform, horizontal axis wind turbine blade were developed using Hamilton's principle. A mathematical ordering scheme which was consistent with the assumption of a slender beam was used to discard some higher-order elastic and inertial terms in the second-degree nonlinear equations. The blade aerodynamic loading which was employed accounted for both wind shear and tower shadow and was obtained from strip theory based on a quasi-steady approximation of two-dimensional, incompressible, unsteady, airfoil theory. The resulting equations had periodic coefficients and were suitable for determining the aeroelastic stability and response of large horizontal-axis wind turbine blades. R.E.S.

N80-26775*# Boeing Engineering and Construction, Seattle, Wash.
MOD-2 WIND TURBINE SYSTEM CONCEPT AND PRELIMINARY DESIGN REPORT. VOLUME 2: DETAILED REPORT
Jul. 1979 269 p
(Contracts DEN3-2; DE-A101-793T-20305)
(NASA-CR-159609; DOE/NASA-0002-80/2) Avail: NTIS HC A12/MF A01 CSCL 10A

The configuration development of the MOD-2 wind turbine system (WTS) is documented. The MOD-2 WTS project is a continuation of DOE programs to develop and achieve early commercialization of wind energy. The MOD-2 is design optimized for commercial production rates which, in multiunit installations, will be integrated into a utility power grid and achieve a cost of electricity at less than four cents per kilowatt hour. J.M.S.

N80-26779*# General Electric Co., Philadelphia, Pa. Space Sciences Lab.
PARAMETRIC STUDY OF PROSPECTIVE EARLY COMERCIAL MHD POWER PLANTS (PSPEC). GENERAL ELECTRIC COMPANY, TASK 1: PARAMETRIC ANALYSIS Final Report
C. H. Marston, F. N. Alyea, D. J. Bender, L. K. Davis, T. C. Dellinger, J. G. Hnat, E. H. Komito, C. A. Peterson, D. A. Rogers, A. J. Roman et al Feb. 1980 358 p refs Prepared in cooperation with Foster Wheeler Corp., Livingston, N.J., Hooker Chemical Co., Niagara Falls, N.Y. and Bechtel National, Inc., San Francisco
(Contract DEN3-52; EF-77-A01-2674)
(NASA-CR-159634; DOE/NASA/0052-79/1) Avail: NTIS

HC A16/MF A01 CSCL 10B

The performance and cost of moderate technology coal-fired open cycle MHD/steam power plant designs which can be expected to require a shorter development time and have a lower development cost than previously considered mature OCMHD/steam plants were determined. Three base cases were considered: an indirectly-fired high temperature air heater (HTAH) subsystem delivering air at 2700 F, fired by a state of the art atmospheric pressure gasifier, and the HTAH subsystem was deleted and oxygen enrichment was used to obtain requisite MHD combustion temperature. Coal pile to bus bar efficiencies in ease case 1 ranged from 41.4% to 42.9%, and cost of electricity (COE) was highest of the three base cases. For base case 2 the efficiency range was 42.0% to 45.6%, and COE was lowest. For base case 3 the efficiency range was 42.9% to 44.4%, and COE was intermediate. The best parametric cases in bases cases 2 and 3 are recommended for conceptual design. Eventual choice between these approaches is dependent on further evaluation of the tradeoffs among HTAH development risk, O2 plant integration, and further refinements of comparative costs. J.M.S.

N80-27803*# Wichita State Univ., Kans.
FEASIBILITY STUDY OF AILERON AND SPOILER CONTROL SYSTEMS FOR LARGE HORIZONTAL AXIS WIND TURBINES Final Report
W. H. Wentz, Jr., M. H. Snyder, and J. T. Calhoun May 1980 69 p refs
(Grant NsG-3277; Contract EX-76-I-01-1028)
(NASA-CR-159856; DOE/NASA/3277-1; WER-10) Avail: NTIS HC A04/MF A01 CSCL 10A

The feasibility of using aileron or spoiler controls as alternates to pitch control for large horizontal axis wind turbines was studied. The NASA Mod-0 100 kw machine was used as the basis for the study. Specific performance studies were conducted for 20% chord ailerons over the outboard 30% span, and for 10% chord spoilers over the same portion of the span. Both control systems utilized control deflections up to 60 deg. Results of the study show that either ailerons or spoilers can provide the control necessary to limit turbine power in high wind conditions. The aileron system, as designed, provides overspeed protection at hurricane wind speeds, low wind speed starting torque of 778 N-m (574 ft. lb) at 3.6 m/sec, and a 1.3 to 1.5% increase in annual energy compared to a fixed pitch rotor. The aileron control system preliminary design study includes aileron loads analysis and the design of a failsafe flyweight actuator for overspeed protection in the event of a hydraulic system failure. L.F.M.

N80-27808*# Spectrolab, Inc., Sylmar, Calif.
SCREEN PRINTING TECHNOLOGY APPLIED TO SILICON SOLAR CELL FABRICATION Final Report, Nov. 1977 Feb. 1979
Jay W. Thornhill and William E. Sipperly Apr. 1980 64 p refs
(Contract NAS3-20826)
(NASA-CR-159789) Avail: NTIS HC A04/MF A01 CSCL 10A

The process for producing space qualified solar cells in both the conventional and wraparound configuration using screen printing techniques was investigated. Process modifications were chosen that could be easily automated or mechanized. Work was accomplished to optimize the tradeoffs associated with gridline spacing, gridline definition and junction depth. An extensive search for possible front contact metallization was completed. The back surface field structures along with the screen printed back contacts were optimized to produce open circuit voltages of at least an average of 600 millivolts. After all intended modifications on the process sequence were accomplished, the cells were exhaustively tested. Electrical tests at AMO and 28 C were made before and after boiling water immersion, thermal shock, and storage under conditions of high temperature and high humidity. L.F.M.

N80-28860*# Spectrolab, Inc., Sylmar, Calif.
COPLANAR BACK CONTACTS FOR THIN SILICON SOLAR CELLS Final Report, Jul. 1978 Dec. 1979
Jay W. Thornhill and W. E. Sipperly Mar 1980 36 p refs
(Contract NAS3-21251)
(NASA-CR-159811) Avail: NTIS HC A03/MF A01 CSCL 10A

A process for fabricating 2 to 3 mil wraparound solar cells was formulated. Sample thin wraparound cells were fabricated using this process. The process used a reinforced perimeter construction to reduce the breakage that occurs during handling of the wafers. A retracting piston post was designed and fabricated to help minimize the breakage that occurs during the screen printing process. Two alternative methods of applying the aluminum back surface field were investigated. In addition to the standard screen printed back surface field, both spin-on and evaporated aluminum techniques were researched. Neither spin-on nor evaporated aluminum made any noticeable improvement over the screen printing technique. A fine screen mesh was chosen for the application of the aluminum paste back surface field. The optimum time and temperature for firing the aluminum turned out to be thirty seconds at 850 C. The development work on the dielectric included looking at three dielectrics for the wraparound application. Transene 1000, Thick Film Systems 1126RCB and an in house formulation 61-2-2A were all tested. Cells with pre-dielectric thickness of 3.0-0-3.5 mils using Transene 1000 as the wraparound dielectric and the procedure outlined above showed an average efficiency of 10.7 percent. Thinner cells were fabricated, but had an unacceptable yield and efficiency. R.E.S.

N80-28862*# General Dynamics/Convair, San Diego, Calif.
STUDY OF POWER MANAGEMENT TECHNOLOGY FOR ORBITAL MULTI-100KWe APPLICATIONS. VOLUME 2: STUDY RESULTS Final Report
J. W. Mildice 15 Jul. 1980 293 p 3 Vol.
(Contract NAS3-21757)
(NASA-CR-159834-Vol-2; GDC-ASP-80-015) Avail: NTIS HC A13/MF A01 CSCL 10B

The preliminary requirements and technology advances required for cost effective space power management systems for multi-100 kilowatt requirements were identified. System requirements were defined by establishing a baseline space platform in the 250 KE KWe range and examining typical user loads and interfaces. The most critical design parameters identified for detailed analysis include: increased distribution voltages and space plasma losses, the choice between ac and dc distribution systems, shuttle servicing effects on reliability, life cycle costs, and frequency impacts to power management system and payload systems for AC transmission. The first choice for a power management system for this kind of application and size range is a hybrid ac/dc combination with the following major features: modular design and construction-sized minimum weight/life cycle cost; high voltage transmission (100 Vac RMS); medium voltage array < or = 440 Vdc); resonant inversion; transformer rotary joint; high frequency power transmission line > or = 20 KHz); energy storage on array side or rotary joint; fully redundant; and 10 year life with minimal replacement and repair. J.M.S.

N80-28866*# Midwest Research Inst., Kansas City, Mo.
THERMAL ENERGY STORAGE SYSTEMS USING FLUIDIZED BED HEAT EXCHANGERS Final Report, Jan. 1979 - Jan. 1980
Tom Weast and Larry Shannon Jun. 1980 209 p
(Contracts DEN3-96; EC-77-A-31-1034)
(NASA-CR-159868; DOE/NASA/0096-1) Avail: NTIS HC A10/MF A01 CSCL 10C

A rotary cement kiln and an electric arc furnace were chosen for evaluation to determine the applicability of a fluid bed heat exchanger (FBHX) for thermal energy storage (TES). Multistage shallow bed FBHX's operating with high temperature differences were identified as the most suitable for TES applications. Analysis of the two selected conceptual systems included establishing a plant process flow configuration, an operational scenario, a preliminary FBHX/TES design, and parametric analysis. A computer model was developed to determine the effects of the number of stages, gas temperatures, gas flows, bed materials, charge and discharge time, and parasitic power required for operation. The maximum national energy conservation potential of the cement plant application with TES is 15.4 million barrels of oil or 3.9 million tons of coal per year. For the electric arc furnace application the maximum national conservation potential with TES is 4.5 million barrels of oil or 1.1 million tons of coal per year. Present time of day utility rates are near the breakeven point required for the TES system. Escalation of on-peak energy due to critical fuel shortages could make the FBHX/TES applications economically attractive in the future. E.D.K.

N80-29845*# General Dynamics/Convair, San Diego, Calif.
STUDY OF POWER MANAGEMENT TECHNOLOGY FOR ORBITAL MULTI-100KWe APPLICATIONS. VOLUME 3: REQUIREMENTS
J. W. Mildice 15 Jul. 1980 37 p refs 3 Vol.
(Contract NAS3-21757)
(NASA-CR-159834; GDC-ASP-80-015) Avail: NTIS HC A03/MF A01 CSCL 10B

Mid to late 1980's power management technology needs to support development of a general purpose space platform, capable of suplying 100 to 250 KWe to a variety of users in low Earth orbit are examined. A typical, shuttle assembled and supplied space platform is illustred, along with a group of payloads which might reasonably be expected to use such a facility. Examination of platform and user power needs yields a set of power requirements used to evaluate power management options for life cycle cost effectivness. The most cost effective ac/dc and dc systems are evaluated, specifically to develop system details which lead to technology goals, including: array and transmission voltages, best frequency for ac power transmission, and advantages and disadvantages of ac and dc systems for this application. System and component requirements are compared with the state-of-the-art to identify areas where technological development is required. Author

N80-29852*# Communications Satellite Corp., Clarksburg, Md.
THIN n-i-p RADIATION-RESISTANT SOLAR CELL FEASIBILITY STUDY Final Report
J. F. Allison, R. A. Arndt, and A. Meulenberg, Jr. Jun. 1980 70 p refs
(Contract NAS3-21280)
(NASA-CR-159871) Avail: NTIS HC A04/MF A01 CSCL 10A

Silicon solar cells were fabricated to verify the predictions that: (1) thin n(+)pp(+) cells can provide high values of open circuit voltage even when high resistivity base material (> 1000 omega-cm) is used; (2) cells with good p(+) back contacts will display an increase in open circuit voltage with decreasing cell thickness; and (3) high quality, thin, high resistivity, solar cells can be made using processing compatible with conventional practice. Analysis of I-V and spectral response measurements of these cells confirmed theoretical predictions and thereby pointed to voltages beyond the near 600 mV obtained in this study. Author

N80-29857*# Honeywell, Inc., Minneapolis, Minn. Technology Strategy Center.
ACTIVE HEAT EXCHANGE SYSTEM DEVELOPMENT FOR LATENT HEAT THERMAL ENERGY STORAGE Final Report
R. T. LeFrois and A. K. Mathur Apr. 1980 226 p
(Contract DEN3-38)
(NASA-CR-159727; DOE/NASA/0038-80/2; HI-79188) Avail: NTIS HC A11/MF A01 CSCL 10C

Five tasks to select, design, fabricate, test and evaluate candidate active heat exchanger modules for future applications to solar and conventional utility power plants were discussed. Alternative mechanizations of active heat exchange concepts were analyzed for use with heat of fusion phase change materials (PCMs) in the temperature range of 250 to 350 C. Twenty-six heat exchange concepts were reviewed, and eight were selected for detailed assessment. Two candidates were selected for small-scale experimentation: a coated tube and shell heat exchanger and a direct contact reflux boiler. A dilute eutectic mixture of sodium nitrate and sodium hydroxide was selected as the PCM from over 50 candidate inorganic salt mixtures. Based on a salt screening process, eight major component salts were selected initially for further evaluation. The most attractive major components in the temperature range of 250 to 350 C appeared to be $NaNO_3$, $NaNO_2$, and NaOH. Sketches of the two active heat exchange concepts selected for test are given. R.K.G.

N80-29860*# Jet Propulsion Lab., California Inst. of Tech., Pasadena. Solar Thermal Power Systems.
HIGH TEMPERATURE THERMAL ENERGY STORAGE IN STEEL AND SAND
Robert H. Turner 15 Dec. 1979 93 p Sponsored by NASA and DOE
(NASA-CR-159708; DOE/NASA/0100-79/1; JPL-PUB-80-35) Avail: NTIS HC A05/MF A01 CSCL 10C

The technical and economic potential for high temperature (343 C, 650 F) thermal energy storage in hollow steel ingots, pipes embedded in concrete, and for pipes buried in sand was evaluated. Because it was determined that concrete would separate from pipes due to thermal stresses, concrete was replaced by sand, which is free from thermal stresses. Variations of the steel ingot concept were not cost effective compared to the sand-pipe approach, therefore, the sand-pipe thermal storage unit (TSU) was evaluated in depth to assess the approximate tube spacing requirements consistent with different system performance characteristics and also attendant system costs. For large TSUs which do not require fast response times, the sand-pipe approach offers attractive possibilities. A pipe diameter about 9 cm (3.5 in) and pipe spacing of approximately 25 cm (10 in), with sand filling the interspaces, appears appropriate. Such a TSU system designed for 8 hours charge/discharge cycle has an energy unit storage cost (CE) of $2.63/kWhr-t and a power unit storage cost (Cp) of $42/kW-t (in 1977 dollars). A.R.H.

N80-30888*# General Electric Co., Fairfield, Conn. Energy Technology Operation.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 6: COMPUTER DATA. PART 1: COAL-FIRED NOCOGENERATION PROCESS BOILER, SECTION A Final Report
W. F. Knightly May 1980 469 p
(Contract DEN3-31)
(NASA-CR-159770-Pt-1-A; DOE/NASA/0031-80/6-Vol-6-Pt-1A; GE80ET0105-Vol-6-Pt-1A) Avail: NTIS HC A20/MF A01 CSCL 10B

About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on site gasification of coal. Computer generated reports of the fuels consumption and savings, capital costs, economics and emissions of the cogeneration energy conversion systems (ECS's) heat and power matched to the individual industrial processes are presented. National fuel and emissions savings are also reported for each ECS assuming it alone is implemented. Two nocogeneration base cases are included: coal fired and residual fired process boilers. T.M.

N80-30889*# General Electric Co., Fairfield, Conn. Energy Technology Operation.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 6: COMPUTER DATA. PART 1: COAL-FIRED NOCOGENERATION PROCESS BOILER, SECTION B Final Report
W. F. Knightly May 1980 480 p
(Contract DEN3-31)
(NASA-CR-159770-Pt-1-B; DOE/NASA/0031-80/6-Vol-6-Pt-1B; GE80ET0105-Vol-6-Pt-1B) Avail: NTIS HC A21/MF A01

CSCL 10B

About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on site gasification of coal. Computer generated reports of the fuel consumption and savings, capital costs, economics and emissions of the cogeneration energy conversion systems (ECS's) heat and power matched to the individual industrial processes are presented. National fuel and emissions savings are also reported for each ECS assuming it alone is implemented. Two nocogeneration base cases are included: coal fired and residual fired process boilers. T.M.

N80-30890*# General Electric Co., Fairfield, Conn. Energy Technology Operation.

COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 6: COMPUTER DATA. PART 2: RESIDUAL-FIRED NOCOGENERATION PROCESS BOILER Final Report

W. F. Knightly May 1980 296 p
(Contract DEN3-31)
(NASA-CR-159770-Pt-2; DOE/NASA/0031-80/6-Vol-6-Pt-2; GE80ET0105-Vol-6-Pt-2) Avail: NTIS HC A13/MF A01 CSCL 10B

About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on site gasification of coal. Computer generated reports of the fuel consumption and savings, capital costs, economics and emissions of the cogeneration energy conversion systems (ECS's) heat and power matched to the individual industrial processes are presented. National fuel and emissions savings are also reported for each ECS assuming it alone is implemented. Two nocogeneration base cases are included: coal fired and residual fired process boilers. T.M.

N80-31869*# United Technologies Corp., South Windsor, Conn. Power Systems Div.

COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 3: ENERGY CONVERSION SYSTEM CHARACTERISTICS Final Report

Jan. 1980 283 p refs
(Contracts DEN3-30; EC-77-A-31-1062)
(NASA-CR-159761; DOE/NASA/0030-80/3-Vol-3; UTC-FCR-1333-Vol-3) Avail: NTIS HC A13/MF A01 CSCL 10B

Six current and thirty-six advanced energy conversion systems were defined and combined with appropriate balance of plant equipment. Twenty-six industrial processes were selected from among the high energy consuming industries to serve as a frame work for the study. Each conversion system was analyzed as a cogenerator with each industrial plant. Fuel consumption, costs, and environmental intrusion were evaluated and compared to corresponding traditional values. The advanced energy conversion technologies indicated reduced fuel consumption, costs, and emissions. Fuel energy savings of 10 to 25 percent were predicted compared to traditional on site furnaces and utility electricity. With the variety of industrial requirements, each advanced technology had attractive applications. Fuel cells indicated the greatest fuel energy savings and emission reductions. Gas turbines and combined cycles indicated high overall annual savings. Steam turbines and gas turbines produced high estimated returns. In some applications, diesels were most efficient. The advanced technologies used coal derived fuels, or coal with advanced fluid bed combustion or on site gasifications. Data and information for both current and advanced energy conversion technology are presented. Schematic and physical descriptions, performance data, equipment cost estimates, and predicted emissions are included. Technical developments which are needed to achieve commercialization in the 1985-2000 period are identified. R.K.G.

N80-31870*# General Electric Co., Philadelphia, Pa. Thermal Power Systems Engineering.

COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 3: INDUSTRIAL PROCESSES Final Report

W. B. Palmer, H. E. Gerlaugh, and R. R. Priestley Apr. 1980 478 p Sponsored by DOE
(Contract DEN3-31)
(NASA-CR-159767; DOE/NASA/0031-80/3-Vol-3; GE80ET0104-Vol-3) Avail: NTIS HC A21/MF A01 CSCL 10B

Cogenerating electric power and process heat in single energy conversion systems rather than separately in utility plants and in process boilers is examined in terms of cost savings. The use of various advanced energy conversion systems are examined and compared with each other and with current technology systems for their savings in fuel energy, costs, and emissions in individual plants and on a national level. About fifty industrial processes from the target energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on site gasification of coal. An attempt was made to use consistent assumptions and a consistent set of ground rules specified by NASA for determining performance and cost. Data and narrative descriptions of the industrial processes are given. R.K.G.

N80-31882*# Westinghouse Research and Development Center, Pittsburgh, Pa.

CELL MODULE AND FUEL CONDITIONER Quarterly Report, Apr. - Jun. 1980

D. Q. Hoover, Jr. Jul. 1980 75 p
(Contracts DEN3-161; DE-AI 03-79ET-11272)
(NASA-CR-159888; DOE/NASA/0161-4; Rept-80-9E6-MARED-R3; QR-3) Avail: NTIS HC A04/MF A01 CSCL 10A

The computer code for the detailed analytical model of the MK-2 stacks is described. An ERC proprietary matrix is incorporated in the stacks. The mechanical behavior of the stack during thermal cycles under compression was determined. A 5 cell stack of the MK-2 design was fabricated and tested. Designs for the next three stacks were selected and component fabrication initiated. A 3 cell stack which verified the use of wet assembly and a new acid fill procedure were fabricated and tested. Components for the 2 kW test facility were received or fabricated and construction of the facility is underway. The definition of fuel and water is used in a study of the fuel conditioning subsystem. Kinetic data on several catalysts, both crushed and pellets, was obtained in the differential reactor. A preliminary definition of the equipment requirements for treating tap and recovered water was developed. S.J.

N80-33859*# General Electric Co., Schenectady, N. Y.

COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 4: ENERGY CONVERSION SYSTEMS

D. H. Brown, H. E. Gerlaugh, and R. R. Priestley Apr. 1980 178 p refs
(Contract DEN3-31)
(NASA-CR-159768; GE80ET0103-Vol-4; DOE/NASA/0031-80/4-Vol-4) Avail: NTIS HC A09/MF A01 CSCL 10B

industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed-cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum-based residual and distillate liquid fuels, and low Btu gas obtained through the on-site gasification of coal. An attempt was made to use consistent assumptions and a consistent set of ground rules specified by NASA for determining performance and cost. The advanced and commercially available cogeneration energy conversion systems studied in CTAS are fined together with their performance, capital costs, and the research and developments required to bring them to this level of performance.

Author

N80-33860*# General Electric Co., Schenectady, N. Y. Energy Technology Operation.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 6: COMPUTER DATA. PART 1: COAL-FIRED NOCOGENERATION PROCESS BOILER, SECTION A Final Report
W. F. Knightly May 1980 481 p refs Prepared for DOE 6 Vol.
(Contract DEN3-31)
(NASA-CR-159770-Pt-1; GE80ET0105-Vol-6-Pt-1; DOE/NASA/0031-80/6) Avail: NTIS HC A21/MF A01 CSCL 10B

Various advanced energy conversion systems (ECS) are compared with each other and with current technology systems for their savings in fuel energy, costs, and emissions in individual plants and on a national level. About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidates which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on-site gasification of coal. Computer generated reports of the fuel consumption and savings, capital costs, economics and emissions of the cogeneration energy conversion systems (ECS's) heat and power matched to the individual industrial processes are presented for coal fired process boilers. National fuel and emissions savings are also reported for each ECS assuming it alone is implemented.

Author

N80-33861*# General Electric Co., Schenectady, N. Y.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 6: COMPUTER DATA. PART 2: RESIDUAL-FIRED NOCOGENERATION PROCESS BOILER Final Report
W. F. Knightly May 1980 287 p
(Contract DEN3-31)
(NASA-CR-159770-Pt-2; GE80ET0105-Vol-6-Pt-2; DOE/NASA/0031-80/6-Vol-6-Pt-2) Avail: NTIS HC A13/MF A01 CSCL 10B

Computer generated data on the performance of the cogeneration energy conversion system are presented. Performance parameters included fuel consumption and savings, capital costs, economics, and emissions of residual fired process boilers.

T.M.

N80-33862*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MOD-2 WIND TURBINE FARM STABILITY STUDY Final Report
E. N. Hinrichsen Jun. 1980 170 p refs
(Contracts DEN3-134; DE-AI01-79ET-20305)
(NASA-CR-165156; R35-40; DOE/NASA/0134-1) Avail: NTIS HC A08/MF A01 CSCL 10A

The dynamics of single and multiple 2.5 ME, Boeing MOD-2 wind turbine generators (WTGs) connected to utility power systems were investigated. The analysis was based on digital simulation. Both time response and frequency response methods were used. The dynamics of this type of WTG are characterized by two torsional modes, a low frequency 'shaft' mode below 1 Hz and an 'electrical' mode at 3-5 Hz. High turbine inertia and low torsional stiffness between turbine and generator are inherent features. Turbine control is based on electrical power, not turbine speed as in conventional utility turbine generators. Multi-machine dynamics differ very little from single machine dynamics.

T.M.

A80-25099 * # **Coupled generator and combustor performance calculations for potential early commercial MHD power plants.** T. C. Dellinger, J. G. Hnat, and C. H. Marston (GE Space Sciences Laboratory, King of Prussia, Pa.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 18th, Butte, Mont., June 18-20, 1979, Preprints. (A80-25061 09-31) Bozeman, Mont., Montana State University, 1979, p. G.5.1-G.5.11. 8 refs. Contract No. DEN3-52.

A parametric study of the performance of the MHD generator and combustor components of potential early commercial open-cycle MHD/steam power plants is presented. Consideration is given to the effects of air heater system concept, MHD combustor type, coal type, thermal input power, oxygen enrichment of the combustion, subsonic and supersonic generator flow and magnetic field strength on coupled generator and combustor performance. The best performance is found to be attained with a 3000 F, indirectly fired air heater, no oxygen enrichment, Illinois no. 6 coal, a two-stage cyclone combustor with 85% slag rejection, a subsonic generator, and a magnetic field configuration yielding a constant transverse electric field of 4 kV/m. Results indicate that optimum net MHD generator power is generally compressor-power-limited rather than electric-stress-limited, with optimum net power a relatively weak function of operating pressure.

A.L.W.

45 ENVIRONMENT POLLUTION

Includes air, noise, thermal and water pollution; environment monitoring; and contamination control.

N80-13721*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN ANALYTICAL STUDY OF NITROGEN OXIDES AND CARBON MONOXIDE EMISSIONS IN HYDROCARBON COMBUSTION WITH ADDED NITROGEN, PRELIMINARY RESULTS

David A. Bittker [1979] 17 p refs Proposed for presentation at the 25th Intern. Gas Turbine Conf., New Orleans, 9-13 Mar. 1980; sponsored by ASME
(Contract EF-77-A-01-2593)
(NASA-TM-79296; DOE/NASA/2593-79/10) Avail: NTIS HC A02/MF A01 CSCL 13B

The effect of combustor operating conditions on the conversion of fuel-bound nitrogen (FBN) to nitrogen oxides NO sub x was analytically determined. The effect of FBN and of operating conditions on carbon monoxide (CO) formation was also studied. For these computations, the combustor was assumed to be a two stage, adiabatic, perfectly-stirred reactor. Propane-air was used as the combustible mixture and fuel-bound nitrogen was simulated by adding nitrogen atoms to the mixture. The oxidation of propane and formation of NO sub x and CO were modeled by a fifty-seven reaction chemical mechanism. The results for NO sub x and CO formation are given as functions of primary and secondary stage equivalence ratios and residence times. R.E.S.

N80-14581*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SULFATE AND NITRATE COLLECTED BY FILTER SAMPLING NEAR THE TROPOPAUSE

Francis M. Humenik, Erwin A. Lezberg, and Dumas A. Otterson Jan. 1980 30 p refs
(NASA-TP-1567; E-073) Avail: NTIS HC A03/MF A01 CSCL 13B

Filter samples collected near the tropopause with an F-106 aircraft and two Boeing 747 aircraft were analyzed for sulfate and nitrate ion content. Within the range of routine commercial flight altitudes (at or below 12.5 km), stratospheric mass mixing ratios for the winter-spring group averaged 0.26 ppbm for sulfate and 0.35 ppbm for nitrate. For the summer-fall group, stratosphere mixing ratios averaged 0.13 ppbm and 0.25 ppbm for sulfate and nitrate, respectively. Winter-spring group tropospheric mass mixing ratios averaged 0.08 ppbm for sulfate and 0.10 ppbm for nitrate, while summer-fall group tropospheric mixing ratios averaged 0.05 ppbm for sulfate and 0.08 ppbm for nitrate. Correlations of the filter data with available ozone data suggest that the sulfate and nitrate are transported from the stratosphere to the troposphere. K.L.

N80-21892*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPES VL0011 AND VL0013 Progress Report, 10 Jan. - 2 Oct. 1977

J. D. Holdeman, Thomas J. Dudzinski, and Marvin W. Tiefermann Mar. 1979 63 p refs
(NASA-TM-81462; E-393) Avail: NTIS HC A04/MF A01 CSCL 13B

In-situ measurements of atmospheric ozone, carbon monoxide, clouds, and related meteorological and flight information obtained during 1122 flights of aircraft VH-EBE and N655PA from January 10 through October 2, 1977 are reported. In addition, tropopause pressures obtained from time and space interpolation of achieved data for the dates of the flights are included. R.E.S.

N80-23875*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ASSESSMENT OF POTENTIAL EXPOSURE TO FRIABLE INSULATION MATERIALS CONTAINING ASBESTOS

Walter S. Kim and David E. Kuivinen Apr. 1980 41 p refs
(NASA-TM-81435; E-359) Avail: NTIS HC A03/MF A01 CSCL 13B

Asbestos and the procedures for assessing potential exposure hazards are discussed. Assessment includes testing a bulk sample of the suspected material for the presence of asbestos, and monitoring the air, if necessary. Based on field inspections and laboratory analyses, the health hazard is evaluated, and abatement measures are taken if a potential hazard exists. Throughout the assessment and abatement program, all applicable regulations are administered as specified by the Environmental Protection Agency and the Occupational Safety and Health Administration. R.E.S.

N80-27832*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COORDINATED AIRCRAFT AND SHIP SURVEYS FOR DETERMINING IMPACT OF RIVER INPUTS ON GREAT LAKES WATERS, REMOTE SENSING RESULTS

Charles A. Raquet, Jack A. Salzman, Thom A. Coney, Roger A. Svehla, Donald F. Shook, and Richard T. Gedney Jul. 1980 105 p refs
(NASA-TP-1694; E-172) Avail: NTIS HC A06/MF A01 CSCL 13B

The remote sensing results of aircraft and ship surveys for determining the impact of river effluents on Great Lakes waters are presented. Aircraft multi-spectral scanner data were acquired throughout the spring and early summer of 1976 at five locations: the West Basin of Lake Erie, Genesee River - Lake Ontario, Menomonee River - Lake Michigan, Grand River - Lake Michigan, and Nemadji River - Lake Superior. Multispectral scanner data and ship surface sample data are correlated resulting in 40 contour plots showing large-scale distributions of parameters such as total suspended solids, turbidity, Secchi depth, nutrients, salts, and dissolved oxygen. The imagery and data analysis are used to determine the transport and dispersion of materials from the river discharges, especially during spring runoff events, and to evaluate the relative effects of river input, resuspension, and shore erosion. Twenty-five LANDSAT satellite images of the study sites are also included in the analysis. Examples of the use of remote sensing data in quantitativley estimating total particulate loading in determining water types, in assessing transport across international boundaries, and in supporting numerical current modeling are included. The importance of coordination of aircraft and ship lake surveys is discussed, including the use of telefacsimile for the transmission of imagery. J.M.S.

A80-45005 * # **Quantitative interpretation of Great Lakes remote sensing data.** D. F. Shook, J. Salzman, R. A. Svehla, and R. T. Gedney (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Geophysical Research,* vol. 85, July 20, 1980, p. 3991-3996. 15 refs.

The paper discusses the quantitative interpretation of Great Lakes remote sensing water quality data. Remote sensing using color information must take into account (1) the existence of many different organic and inorganic species throughout the Great Lakes, (2) the occurrence of a mixture of species in most locations, and (3) spatial variations in types and concentration of species. The radiative transfer model provides a potential method for an orderly analysis of remote sensing data and a physical basis for developing quantitative algorithms. Predictions and field measurements of volume reflectances are presented which show the advantage of using a radiative transfer model. Spectral absorptance and backscattering coefficients for two inorganic sediments are reported. A.T.

N80-18686*# ORI, Inc., Silver Spring, Md.
AERIAL APPLICATIONS DISPERSAL SYSTEMS CONTROL REQUIREMENTS STUDY Final Report
J. S. Bauchspies, W. L. Cleary, W. F. Rogers, W. Simpson, and G. S. Sanders 15 Feb. 1980 84 p refs
(Contract NAS3-21714)
(NASA-CR-159781; ORI-TR-1686) Avail: NTIS HC A05/MF A01 CSCL 13B

Performance deficiencies in aerial liquid and dry dispersal systems are identified. Five control system concepts are explored: (1) end of field on/off control, (2) manual control of particle size and application rate from the aircraft; (3) manual control of deposit rate on the field; (4) automatic alarm and shut-off control; and (5) fully automatic control. Operational aspects of the concepts and specifications for improved control configurations are discussed in detail. A research plan to provide the technology needed to develop the proposed improvements is presented along with a flight program to verify the benefits achieved. K.L.

47 METEOROLOGY AND CLIMATOLOGY

Includes weather forecasting and modification.

A80-35719 * # **Modified power law equations for vertical wind profiles.** D. A. Spera and T. R. Richards (NASA, Lewis Research Center, Cleveland, Ohio). In: Conference and Workshop on Wind Energy Characteristics and Wind Energy Siting, Portland, Ore., June 19-21, 1979, Proceedings. (A80-35716 14-44) Boston, Mass., American Meteorological Society, 1979, p. 47-56; Discussion, p. 57, 58. 14 refs.

In an investigation of windpower plant siting, equations are presented and evaluated for a wind profile model which incorporates both roughness and wind speed effects, while retaining the basic simplicity of the Hellman power law. These equations recognize the statistical nature of wind profiles and are compatible with existing analytical models and recent wind profile data. Predictions of energy output based on the proposed profile equations are 10% to 20% higher than those made with the 1/7 power law. In addition, correlation between calculated and observed blade loads is significantly better at higher wind speeds when the proposed wind profile model is used than when a constant power model is used. B.J.

A80-32520 * **Comments on 'Experimental evidence for interhemispheric transport from airborne carbon monoxide measurements'.** P. D. Falconer and R. W. Pratt (New York, State University, Albany, N.Y.). *Journal of Applied Meteorology*, vol. 19, Mar. 1980, p. 338, 339; Reply, p. 339, 340. 8 refs. Grant No. NsG-3138; Contract No. NAS3-21606.

51 LIFE SCIENCES (GENERAL)

Includes genetics

N80-24983*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY RESULTS OF FAST NEUTRON TREATMENTS IN CARCINOMA OF THE PANCREAS
Reinhard Gahbauer, Kyee Y. Koh, Antonio Rodriguez-Antunez, Gwynn L. Jelden, Robert F. Turco, John Horton, Ronald Bukowski, Ronald Reimer, James Blue, William Roberts et al 1980 4 p
Presented at the National Pancreatic Proj., New Orleans, 18 Apr. 1980 Prepared in cooperation with Cleveland Clinic Foundation, Ohio
(NASA-TM-81516; E-460) Avail: NTIS HC A02/MF A01 CSCL 06E

A group of 30 patients with adenocarcinoma of the pancreas including some patients with very advanced disease, were treated with the so-called mixed beam modality employing photon treatments three times per week and neutron treatments twice a week. Two hundred Rads or equivalent Rads (RBE 3.3) were given in daily fractions aiming at a total dose of 6000 Rads in 6 to 8 weeks. The treatments were well tolerated and significant palliation was achieved in 26 to 30 cases. Twelve months survival was 33 percent with a median survival of 7 months or 210 days. Treatment techniques and localization procedures are discussed. R.E.S.

52 AEROSPACE MEDICINE

Includes physiological factors, biological effects of radiation; and weightlessness

N80-14684* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INTRA-OCULAR PRESSURE NORMALIZATION TECHNIQUE AND EQUIPMENT Patent

Edward F. Baehr, inventor (to NASA) Issued 12 Jun. 1979 5 p Filed 31 Aug. 1977 Supersedes N77-30736 (15 - 21, p 2839)
(NASA-Case-LEW-12955-1; US-Patent-4,157,718; US-Patent-Appl-SN-829318; US-Patent-Class-128-276) Avail: US Patent and Trademark Office CSCL 06B

A method and apparatus is described for safely reducing abnormally high intraocular pressure in an eye during a predetermined time interval. This allows maintenance of normal intraocular pressure during glaucoma surgery. A pressure regulator of the spring-biased diaphragm type is provided with additional bias by a column of liquid. The hypodermic needle can be safely inserted into the anterior chamber of the eye. Liquid is then bled out of the column to reduce the bias on the diaphragm of the pressure regulator and, consequently, the output pressure of the regulator. This lowering pressure of the regulator also occurs in the eye by means of a small second bleed path provided between the pressure regulator and the hypodermic needle.

Official Gazette of the U.S. Patent and Trademark Office

60 COMPUTER OPERATIONS AND HARDWARE

Includes computer graphics and data processing
For components see 33 Electronics and Electrical Engineering

N80-16742*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
INFORM: AN INTERACTIVE DATA COLLECTION AND DISPLAY PROGRAM WITH DEBUGGING CAPABILITY
David S Cwynar Jan 1980 169 p refs
(NASA-TP-1424; E-9810) Avail NTIS HC A08/MF A01 CSCL 09B

A computer program was developed to aid ASSEMBLY language programmers of mini and micro computers in solving the man machine communications problems that exist when scaled integers are involved. In addition to producing displays of quasi-steady state values, INFORM provides an interactive mode for debugging programs, making program patches, and modifying the displays. Auxiliary routines SAMPLE and DATAO add dynamic data acquisition and high speed dynamic display capability to the program. Programming information and flow charts to aid in implementing INFORM on various machines together with descriptions of all supportive software are provided. Program modifications to satisfy the individual user's needs are considered. R.C.T.

61 COMPUTER PROGRAMMING AND SOFTWARE

Includes computer programs, routines, and algorithms.

N80-33104*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NONANALYTIC FUNCTION GENERATION ROUTINES FOR 16-BIT MICROPROCESSORS
James F. Soeder and Maryrita Shaufl Washington Sep. 1980 66 p refs
(NASA-TM-81586, E-565) Avail: NTIS HC A04/MF A01 CSCL 09B

Interpolation techniques for three types (univariate, bivariate, and map) of nonanalytic functions are described. These interpolation techniques are then implemented in scaled fraction arithmetic on a representative 16 bit microprocessor. A FORTRAN program is described that facilitates the scaling, documentation, and organization of data for use by these routines. Listings of all these programs are included in an appendix. L.F.M.

N80-19863*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ALGORITHM FOR CALCULATING TURBINE COOLING FLOW AND THE RESULTING DECREASE IN TURBINE EFFICIENCY
James W. Gauntner Feb. 1980 23 p refs
(NASA-TM-81453; E-384) Avail: NTIS HC A02/MF A01 CSCL 09B

An algorithm is presented for calculating both the quantity of compressor bleed flow required to cool the turbine and the decrease in turbine efficiency caused by the injection of cooling air into the gas stream. The algorithm, which is intended for an axial flow, air routine in a properly written thermodynamic cycle code. Ten different cooling configurations are available for each row of cooled airfoils in the turbine. Results from the algorithm are substantiated by comparison with flows predicted by major engine manufacturers for given bulk metal temperatures and given cooling configurations. A list of definitions for the terms in the subroutine is presented. K.L.

65 STATISTICS AND PROBABILITY

Includes data sampling and smoothing; Monte Carlo method, and stochastic processes.

N80-29088*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
CYCLES TILL FAILURE OF SILVER-ZINC CELLS WITH COMPLETING FAILURES MODES: PRELIMINARY DATA ANALYSIS
Steven M. Sidik, Harold F. Leibecki, and John M. Bozek 1980 48 p refs Presented at Ann. Meeting of the Am. Statist. Assoc., Houston, Tex., 11-14 Aug. 1980
(NASA-TM-81556; E-517) Avail: NTIS HC A03/MF A01 CSCL 14D

One hundred and twenty nine cells were run through charge-discharge cycles until failure. The experiment design was a variant of a central composite factorial in five factors. Preliminary data analysis consisted of response surface estimation of life. Batteries fail under two basic modes; a low voltage condition and an internal shorting condition. A competing failure modes analysis using maximum likelihood estimation for the extreme value life distribution was performed. Extensive diagnostics such as residual plotting and probability plotting were employed to verify data quality and choice of model. Auhtor

A80-40764 * **'Chain pooling' model selection for two-level fixed effects factorial experiments.** A. G. Holms (NASA, Lewis Research Center, Cleveland, Ohio). *Communications in Statistics, Part B: Simulation and Computation,* vol. B9, no. 1, 1980, p. 51-71. 12 refs.

As many as three iterated statistical model deletion procedures are considered for an experiment. Population model coefficients were chosen to simulate a saturated factorial experiment having an unfavorable distribution of parameter values. Using random number studies, three model selection strategies were developed, namely, (1) a strategy to be used in anticipation of large coefficients of variation (neighborhood of 65 percent), (2) strategy to be used in anticipation of small coefficients of variation (4 percent or less), and (3) a security regret strategy to be used in the absence of such prior knowledge. (Author)

66 SYSTEMS ANALYSIS

Includes mathematical modeling; network analysis; and operations research.

N80-16824*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
AN AVERAGING BATTERY MODEL FOR A LEAD-ACID BATTERY OPERATING IN AN ELECTRIC CAR Final Report
John M Bozek Dec. 1979 19 p refs
(Contract EC-77-A-31-1044)
(NASA-TM-79321; DOE/NASA/1044-79/5; E-277) Avail: NTIS HC A02/MF A01 CSCL 12B

A battery model is developed based on time averaging the current or power, and is shown to be an effective means of predicting the performance of a lead acid battery. The effectiveness of this battery model was tested on battery discharge profiles expected during the operation of an electric vehicle following the various SAE J227a driving schedules. The averaging model predicts the performance of a battery that is periodically charged (regenerated) if the regeneration energy is assumed to be converted to retrievable electrochemical energy on a one-to-one basis Author

A80-10035 * # **Computerized systems analysis and optimization of aircraft engine performance, weight, and life cycle costs.** L. H. Fishbach (NASA, Lewis Research Center, Flight Performance Section, Cleveland, Ohio). *NATO, AGARD, Symposium on the Use of Computers as a Design Tool, Munich, West Germany, Sept. 3-6, 1979, Paper.* 20 p. 16 refs.

The paper describes the computational techniques employed in determining the optimal propulsion systems for future aircraft applications and to identify system tradeoffs and technology requirements. The computer programs used to perform calculations for all the factors that enter into the selection process of determining the optimum combinations of airplanes and engines are examined. Attention is given to the description of the computer codes including NNEP, WATE, LIFCYC, INSTAL, and POD DRG. A process is illustrated by which turbine engines can be evaluated as to fuel consumption, engine weight, cost and installation effects. Examples are shown as to the benefits of variable geometry and of the tradeoff between fuel burned and engine weights. Future plans for further improvements in the analytical modeling of engine systems are also described. C.F.W.

67 THEORETICAL MATHEMATICS

Includes topology and number theory.

N80-24129*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FAR-FIELD RADIATION OF AFT TURBOFAN NOISE
Edward J. Rice and Arthur V. Saule 1980 25 p refs Presented at 99th Meeting of the Acoust. Soc. of Am., Atlanta, 21-25 Apr 1980
(NASA-TM-81506; e-444) Avail: NTIS HC A02/MF A01 CSCL 20A

Approximate expressions were developed for the noise radiation from the aft duct. The results of approximate aft radiation equation compare favorably to more exact Wiener-Hopf radiation results. Refraction as well as convective effects in the multiple flow streams is considered. The peak in the radiation pattern, which occurs nearly at engine sideline, is composed of modes with relatively large cut-off ratios. This implies that aft fan radiation will be inherently more difficult to suppress that the fan inlet noise. The theoretical multimodal radiation pattern is compared to experimental data for the first two harmonics of blade passage frequency for three full scale fans at two speeds. The agreement between theory and experiment is quite good. A.R.H.

71 ACOUSTICS

Includes sound generation, transmission and attenuation.
For noise pollution see *45 Environment Pollution.*

N80-12822*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TIME-DEPENDENT DIFFERENCE THEORY FOR NOISE PROPAGATION IN A TWO-DIMENSIONAL DUCT
Kenneth J. Baumeister 1979 13 p refs Presented at 18th Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980; sponsored by AIAA
(NASA-TM-79298; E-249; AIAA-Paper-80-0098) Avail: NTIS HC A02/MF A01 CSCL 20A

A time dependent numerical formulation was derived for sound propagation in a two dimensional straight soft-walled duct in the absence of mean flow. The time dependent governing acoustic-difference equations and boundary conditions were developed along with the maximum stable time increment. Example calculations were presented for sound attenuation in hard and soft wall ducts. The time dependent analysis were found to be superior to the conventional steady numerical analysis because of much shorter solution times and the elimination of matrix storage requirements. R.C.T.

N80-12823*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A TIME DEPENDENT DIFFERENCE THEORY FOR SOUND PROPAGATION IN DUCTS WITH FLOW
K. J. Baumeister 1979 38 p refs Presented at 98th Meeting of the Acoustical Soc. of Am., Salt Lake City, Utah, 26-30 Nov. 1979
(NASA-TM-79302; E-254) Avail: NTIS HC A03/MF A01 CSCL 20A

A time dependent numerical solution of the linearized continuity and momentum equation was developed for sound propagation in a two dimensional straight hard or soft wall duct with a sheared mean flow. The time dependent governing acoustic difference equations and boundary conditions were developed along with a numerical determination of the maximum stable time increments. A harmonic noise source radiating into a quiescent duct was analyzed. This explicit iteration method then calculated stepwise in real time to obtain the transient as well as the steady state solution of the acoustic field. Example calculations were presented for sound propagation in hard and soft wall ducts, with no flow and plug flow. Although the problem with sheared flow was formulated and programmed, sample calculations were not examined. The time dependent finite difference analysis was found to be superior to the steady state finite difference and finite element techniques because of shorter solution times and the elimination of large matrix storage requirements. R.C.T.

N80-12824*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RECIPROCITY PRINCIPLE IN DUCT ACOUSTICS
Young-chung Cho 1979 23 p refs Presented at 97th Meeting of the Acoustical Soc. of Am., Cambridge, Mass., 11-15 Jun. 1979
(NASA-TM-79300; E-250) Avail: NTIS HC A02/MF A01 CSCL 20A

Various reciprocity relations in duct acoustics have been derived on the basis of the spatial reciprocity principle implied in Green's functions for linear waves. The derivation includes the reciprocity relations between mode conversion coefficients for reflection and transmission in nonuniform ducts, and the relation between the radiation of a mode from an arbitrarily terminated duct and the absorption of an externally incident plane wave by the duct. Such relations are well defined as long as the systems remain linear, regardless of acoustic properties of duct nonuniformities which cause the mode conversions. Author

N80-13881*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ASSESSMENT AT FULL SCALE OF EXHAUST NOZZLE TO WING SIZE ON STOL-OTW ACOUSTIC CHARACTERISTICS
U. VonGlahn and D. Grosbeck 1979 27 p refs Presented at 98th Meeting of the Acoustical Soc. of Am., Salt Lake City, 26-30 Nov. 1979
(NASA-TM-79279; E-215) Avail: NTIS HC A03/MF A01 CSCL 20A

On the basis of static aero/acoustic data obtained at model scale, the effect of exhaust nozzle size on flyover noise is evaluated at full scale for different STOL-OTW nozzle configurations. Three types of nozzles are evaluated: a circular/deflector nozzle mounted above the wing; a slot/deflector nozzle mounted on the wing; and a slot nozzle mounted on the wing. The nozzle exhaust plane location, measured from the wing leading edge, was varied from 10 to 46 percent of the wing chord (flaps retracted). Flap angles of 20 deg (takeoff) and 60 deg (approach) are included in the study. Initially, perceived noise levels (PNL) are calculated as a function flyover distance at 152m altitude. From these plots, static EPNL values (defined as flyover relative noise levels), are obtained as functions of nozzle size for equal aerodynamic performance (lift and thrust). The acoustic benefits attributable to nozzle size relative to a given wing chord size are assessed. A.R.H.

N80-14843*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ACOUSTIC CONSIDERATIONS OF FLIGHT EFFECTS ON JET NOISE SUPPRESSOR NOZZLES
U. vonGlahn 1979 26 p refs Presented at the AIAA 18th Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980
(NASA-TM-81377; E-282; AIAA-Paper-80-0164) Avail: NTIS HC A03/MF A01 CSCL 20A

The inflight acoustic characteristics of high velocity jet noise suppressor nozzles for supersonic cruise aircraft were reviewed. The inflight effects at the peak noise level were discussed. Both single and invurted velocity profile multistream suppressor nozzles were considered. The importance of static spectral shape on the noise reduction due to inflight effects was stressed. R.C.T.

N80-15876*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARISON OF INLET SUPPRESSOR DATA WITH APPROXIMATE THEORY BASED ON CUTOFF RATIO
Edward J. Rice and Laurence J. Heidelberg [1979] 28 p refs Presented at the AIAA Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980
(NASA-TM-81386; E-294) Avail: NTIS HC A03/MF A01 CSCL 20A

Inlet suppressor far-field directivity suppression was quantitatively compared with that predicted using an approximate linear design and evaluation method based upon mode cutoff ratio. The experimental data was obtained using a series of cylindrical point-reacting inlet liners on a YF102 engine. The theoretical prediction program is based upon simplified sound propagation concepts derived from exact calculations. These indicate that all of the controlling phenomenon can be approximately correlated with mode cutoff ratio which itself is intimately related to the angles of propagation within the duct. The theory-data comparisons are intended to point out possible deficiencies in the approximate theory which may be corrected. After all theoretical refinements are made, then empirical corrections can be applied. A.R.H.

N80-18882*# National Aeronuutics and Space Administration. Lewis Research Center, Cleveland, Ohio.
APPLICATION OF COHERENCE IN FAN NOISE STUDIES
Joseph R. Balombin Feb. 1980 26 p refs
(NASA-TP-1630; E-157) Avail: NTIS HC A03/MF A01 CSCL 20A

A study of fan noise was made by using the coherence function to obtain far field spectra that were coherent with the fan rotational rate. Choosing fan rotational rate as one of the two variables yielded new information about the far field noise generated during static fan testing. As a result of this coherent data processing, the inlet fan-tone noise present in static testing was determined to be mostly random when the rotor-alone and rotor-stator interaction tones were cut off. After the rotor-alone sound field was cut on, the sound pressure became coherent, and the angular extent of high coherence increased as fan speed was increased. In addition, the sound field was organized as a pattern of lobes whose amplitude varied slowly with time. Additional fan test results indicate that operating the fan with an inflow control device can partially reduce the fan-tone noise levels to those produced by coherent processing. R.E.S.

N80-22045*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPECTRAL STRUCTURE OF PRESSURE MEASUREMENTS MADE IN A COMBUSTION DUCT
J. H. Miles and D. D. Raftopoulos (Toledo Univ.) 1980 46 p refs Presented at 99th Meeting of the Acoust. Soc. of Am., Atlanta, 21-25 Apr. 1980
(NASA-TM-81471; E-404) Avail: NTIS HC A03/MF A01 CSCL 20A

A model for acoustic plane wave propagation in a combustion duct through a confined, flowing gas containing soot particles is presented. The model takes into account only heat transfer between the gas and soot particles. As a result, the model depends on only a single parameter which can be written as the ratio of the soot particle thermal relaxation time to the soot particle mass fraction. The model yields expressions for the attenuation and dispersion of the plane wave which depends only on this single parameter. The model was used to calculate pressure spectra in a combustion duct. The results were compared with measured spectra. For particular values of the single free parameter, the calculated spectra resemble the measured spectra. Consequently, the model, to this extent, explains the experimental measurements and provides some insight into the number and type of particles. Author

N80-22046*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NOISE SUPPRESSION DUE TO ANNULUS SHAPING OF AN INVERTED-VELOCITY-PROFILE COAXIAL NOZZLE
J. Goodykoontz and U. vonGlahn Apr. 1980 27 p refs Presented at 99th Meeting of the Acoust. Soc. of Am., Atlanta, 21-25 Apr. 1980
(NASA-TM-81460; E-389) Avail: NTIS HC A03/MF A01 CSCL 20A

An inverted velocity profile coaxial nozzle for use with supersonic cruise aircraft produces less jet noise than an equivalent conical nozzle. Furthermore, decreasing the annulus height (increasing radius ratio with constant flow) results in further noise reduction benefits. The annulus shape (height) was varied by an eccentric mounting of the annular nozzle with respect to a conical core nozzle. Acoustic measurements were made in the flyover plane below the narrowest portion of the annulus and at 90 deg and 180 deg from this point. The model-scale spectra are scaled up to engine size (1.07 m diameter) and the perceived noise levels for the eccentric and baseline concentric inverted velocity profile coaxial nozzles are compared over a range of operating conditions. The implications of the acoustic benefits derived with the eccentric nozzle to practical applications are discussed. A.R.H.

N80-22047*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NOISE SUPPRESSION DUE TO ANNULUS SHAPING OF CONVENTIONAL COAXIAL NOZZLE
U. vonGlahn and J. Goodykoontz 1980 19 p refs Prepared for the 99th Meeting of the Acoust. Soc. of Am., Altanta, 21-25 Apr. 1980
(NASA-TM-81461; E-390) Avail: NTIS HC A02/MF A01 CSCL 20A

A method which shows that increasing the annulus width of a conventional coaxial nozzle with constant bypass velocity will lower the noise level is described. The method entails modifying a concentric coaxial nozzle to provide an eccentric outer stream annulus while maintaining approximately the same through flow as that for the original concentric bypass nozzle. Acoustical tests to determine the noise generating characteristics of the nozzle over a range of flow conditions are described. The tests involved sequentially analyzing the noise signals and digitally recording the 1/3 octave band sound pressure levels. The measurements were made in a plane passing through the minimum and maximum annulus width points, as well as at 90 degrees in this plane, by rotating the outer nozzle about its axis. Representative measured spectral data in the flyover plane for the concentric nozzle obtained at model scale are discussed. Representative spectra for several engine cycles are presented for both the eccentric and concentric nozzles at engine size. A.W.H.

N80-22048*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN IMPROVED PREDICTION METHOD FOR THE NOISE GENERATED IN FLIGHT BY CIRCULAR JETS
James R. Stone and Francis J. Montegani 1980 33 p refs Prepared for the 99th Meeting of the Acoust. Soc. of Am., Atlanta, 21-25 Apr. 1980
(NASA-TM-81470; E-403) Avail: NTIS HC A03/MF A01 CSCL 20A

A semi-empirical model for predicting the noise generated by jets exhausting from circular nozzles is presented and compared with small-scale static and simulated-flight data. The present method is an updated version of that part of the original NASA aircraft noise prediction program relating to circular jet noise. The earlier method agreed reasonably well with experimental static and flight data for jet velocities up to approximately 520 m/sec. The poorer agreement at higher jet velocities appeared to be due primarily to the manner in which supersonic convection effects were formulated. The purely empirical supersonic convection formulation is replaced in the present method by one based on theoretical considerations. Other improvements of an empirical nature were included based on model-jet/free-jet simulated-flight tests. The effects of nozzle size, jet velocity, jet temperature, and flight are included. A.R.H.

N80-23096*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TIME DEPENDENT DIFFERENCE THEORY FOR SOUND PROPAGATION IN AXISYMMETRIC DUCTS WITH PLUG FLOW
K. J. Baumeister 1980 12 p refs Presented at 6th Aeroacoustics Conf., Hartford, Conn. 4-6 Jun. 1980; sponsored by AIAA
(NASA-TM-81501; E-438) Avail: NTIS HC A02/MF A01 CSCL 20A

The time dependent governing acoustic-difference equations and boundary conditions are developed and solved for sound propagation in an axisymmetric (cylindrical) hard wall duct with a plug mean flow and spinning acoustic modes. The analysis begins with a harmonic sound source radiating into a quiescent duct. This explicit iteration method then calculates stepwise in real time to obtain the transient as well as the 'steady' state solutions of the acoustic field. The time dependent finite difference analysis has two advantages over the steady state finite difference and finite element techniques: (1)the elimination of large matrix storage requirements, and (2)shorter solution times under most conditions. Author

N80-23097*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRESSURE SPECTRA AND CROSS SPECTRA AT AN AREA CONTRACTION IN A DUCTED COMBUSTION SYSTEM
J. H. Miles and D. D. Raftopoulos 1980 12 p refs Presented at 1980 ASME Aerospace Conf., San Francisco, 13-15 Aug. 1980
(NASA-TM-81477; E-411) Avail: NTIS HC A02/MF A01 CSCL 20A

Pressure spectra and cross-spectra at an area contraction in a liquid fuel, ducted, combustion noise test facility are analyzed. Measurements made over a range of air and fuel flows are discussed. Measured spectra are compared with spectra calculated using a simple analytical model. Author

N80-23098*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF INFLOW CONTROL ON INLET NOISE OF A CUT-ON FAN

Richard P. Woodward and Frederick W. Glaser 1980 13 p refs Presented at 6th Aeroacoustics Conf., Hartford, Conn., 4-6 Jun. 1980; sponsored by AIAA

(NASA-TM-81487) Avail: NTIS HC A02/MF A01 CSCL 20A

The control of turbulence and other inflow disturbances in anechoic chambers for static turbofan noise studies was studied. A cut-on, high tip speed fan stage was acoustically tested with three configurations of an inflow control device in an anechoic chamber. Although this was a cut-on design, rotor inflow interaction appeared to be a much stronger source of blade passing tone radiated from the inlet than rotor stator interaction for the 1.6 mean rotor chord separation. Aft external suction applied to the area where the inflow control device joined the inlet produced a further reduction in blade passing tone, suggesting that disturbances in the forward flow on the outside of the inlet were superimposed on the inlet boundary layer and were a significant source of tone noise. M.G.

N80-23100*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FORWARD ACOUSTIC PERFORMANCE OF A SHOCK-SWALLOWING HIGH-TIP-SPEED FAN (QF-13)

James G. Lucas, Richard P. Woodward, and Michael J. MacKinnon May 1980 20 p refs

(NASA-TP-1668; E-202) Avail: NTIS HC A02/MF A01 CSCL 20A

Forward noise and overall aerodynamic performance data are presented for a high-tip-speed fan having rotor blade airfoils designed to alter the conventional leading-edge bow shocks to weak, oblique shocks which are swallowed within the interblade channels. It was anticipated that the swallowed shocks would minimize the generation of multiple-pure-tone noise. In the speed range where the shocks presumably were swallowed, the multiple-tone noise was lowered only about 3 decibels. Comparison with several high-speed fans on a thrust-corrected basis indicates that the present fan was the quietest in total forward noise at low speeds but offered no advantage at high speeds. Author

N80-23101*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HIGHER ORDER MODE PROPAGATION IN NONUNIFORM CIRCULAR DUCTS

Y. C. Cho and K. U. Ingard 1980 11 p refs Presented at the 6th Aeroacoustics Conf., Hartford, 4-6 Jun. 1980; sponsored by AIAA Prepared in cooperation with MIT, Cambridge

(NASA-TM-81481; E-418) Avail: NTIS HC A02/MF A01 CSCL 20A

Higher order mode propagation in a nonuniform circular duct without mean flow was investigated. An approximate wave equation is derived on the assumptions that the duct cross section varies slowly and that mode conversion is negligible. Exact closed form solutions are obtained for a particular class of converging-diverging circular duct which referred to as 'circular cosh duct.' Numerical results are presented in terms of the transmission loss for the various duct shapes and frequencies. The results are applicable to multimodal propagation, single mode propagation, and sound radiation from certain types of contoured inlet ducts, or of sound propagation in a converging-diverging duct of somewhat different shape from a cosh duct. F.O.S.

N80-23102*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN EXPLORATORY SURVEY OF NOISE LEVELS ASSOCIATED WITH A 100kW WIND TURBINE

J. R. Balombin 1980 20 p refs Presented at the 99th Meeting of the Acoustical Soc. of Am., Atlanta, 21-25 Apr. 1980

(NASA-TM-81486; E-424) Avail: NTIS HC A02/MF A01 CSCL 20A

Noise measurements of a 125-foot diameter, 100 kW wind turbine are presented. The data include measurements as functions of distance from the turbine and directivity angle and cover a frequency range from 1 Hz to several kHz. Potential community impact is discussed in terms of A-weighted noise levels relative to background levels, and the intrasonic spectral content. Finally, the change in the sound power spectrum associated with a change in the rotor speed in described. The acoustic impact of this size wind turbine is judged to be minimal. M.G.

N80-25101*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A COMPARISON BETWEEN AN EXISTING PROPELLER NOISE THEORY AND WIND TUNNEL DATA

James H. Dittmar May 1980 41 p refs

(NASA-TM-81519; E-464) Avail: NTIS HC A03/MF A01 CSCL 20A

The noise of three supersonic helical tip speed propellers was compared with the noise predicted by an existing noise theory. Comparisons of the peak blade passage tones showed fairly good agreement beween theory and experiment at the lowest helical tip Mach numbers tested, 0.86 and 1.00, while at higher numbers, the theory predicted higher noise levels than measured. When the differences among the propellers were considered the theory and measurement showed fairly good agreement. Directivity measurements in general showed that the measured blade passage tone data peaked further downstream than the theory predicted. At the cruise design condition the harmonics appeared to fall off faster in the data than the theory indicated. E.D.K.

N80-26115*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MEASURED AND PREDICTED IMPINGEMENT NOISE FOR A MODEL-SCALE UNDER THE WING EXTERNALLY BLOWN FLAP CONFIGURATION WITH A QCSEE TYPE NOZZLE

D. J. McKinzie, Jr Jun. 1980 63 p refs

(NASA-TM-81494; E-432) Avail: NTIS HC A04/MF A01 CSCL 20A

Jet/flap interaction noise was measured and predicted for a small-scale model two-flap, under-the-wing, externally blown flap configuration equipped with and without noise suppression devices. The devices consisted of short spanwise fairings centered in relationship to the jet axis and positioned in the slots between the wing and flaps. The nozzle approximated that of the Quiet Clean Short-haul Experimental Engine (QCSEE). Takeoff noise reductions of 6 dB in the flyover and 5 dB in the sideline plane were obtained over a wide range of radiation angles. Approach noise reductions of about 5 dB were obtained only in the forward quadrant of the flyover plane; no reductions were obtained in the sideline plane. Models of several noise sources were combined analytically to form an overall noise prediction, the results from which compared favorably with the measured data. The aerodynamic performance characteristics for these configurations were substantially the same in the takeoff attitude. However, in the approach attitude, the suppressed configuration produced a 6 percent reduction in the flow turning efficiency. Author

N80-29132*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PREDICTION OF UNSUPPRESSED JET ENGINE EXHAUST NOISE IN FLIGHT FROM STATIC DATA

James R. Stone 1980 26 p refs Presented at 6th Aeroacoustics Conf., Hartford, Conn., 4-6 Jun. 1980; sponsored by AIAA

(NASA-TM-81537; E-491) Avail: NTIS HC A03/MF A01 CSCL 20A

A methodology developed for predicting in-flight exhaust noise from static data is presented and compared with experimental

data for several unsuppressed turbojet engines. For each engine, static data over a range of jet velocities are compared with the predicted jet mixing noise and shock-cell noise. The static engine noise over and above the jet and shock noises is identified as excess noise. The excess noise data are then empirically correlated to smooth the spectral and directivity relations and account for variations in test conditions. This excess noise is then projected to flight based on the assumption that the only effects of flight are a Doppler frequency shift and a level change given by 40 log (1 - m sub O cos theta), where M sub O is the flight Mach number and theta is the observer angle relative to the jet axis.
M.G.

N80-30154*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NUMERICAL TECHNIQUES IN LINEAR DUCT ACOUSTICS Status Report
K. J. Baumeister 1980 23 p refs Proposed for presentation at Winter Ann. Meeting of ASME Chicago, 17-21 Nov. 1980 (NASA-TM-81553; E-513) Avail: NTIS HC A02/MF A01 CSCL 20A

Both finite difference and finite element analyses of small amplitude (linear) sound propagation in straight and variable area ducts with flow, as might be found in a typical turbojet engine duct, muffler, or industrial ventilation system, are reviewed. Both steady state and transient theories are discussed. Emphasis is placed on the advantages and limitations associated with the various numerical techniques. Examples of practical problems are given for which the numerical techniques have been applied.
A.R.H.

A80-18269 * # **Time-dependent difference theory for noise propagation in a two-dimensional duct.** K. J. Baumeister (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0098.* 10 p. 36 refs.

A time-dependent numerical formulation is derived for sound propagation in a two-dimensional straight soft-walled duct in the absence of mean flow. The time-dependent governing acoustic-difference equations and boundary conditions are developed along with the maximum stable time increment. Example calculations are presented for sound attenuation in hard- and soft-wall ducts. The time-dependent analysis has been found to be superior to the conventional steady numerical analysis because of much shorter solution times and the elimination of matrix storage requirements.
(Author)

A80-20951 * # **A time dependent difference theory for sound propagation in ducts with flow.** K. J. Baumeister (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 98th, Salt Lake City, Utah, Nov. 26-30, 1979, Paper.* 36 p. 38 refs.

A time dependent numerical solution of the linearized continuity and momentum equation is developed for sound propagation in a two-dimensional straight hard or soft wall duct with a sheared mean flow. The time dependent governing acoustic-difference equations and boundary conditions are developed along with a numerical determination of the maximum stable time increments. The analysis begins with a harmonic noise source radiating into a quiescent duct. This explicit iteration method then calculates stepwise in real time to obtain the transient as well as the 'steady' state solution of the acoustic field. Example calculations are presented for sound propagation in hard and soft wall ducts, with no flow and with plug flow. Although the problem with sheared flow has been formulated and programmed, sample calculations have not yet been examined. So far, the time dependent finite difference analysis has been found to be superior to the steady state finite difference and finite element techniques because of shorter solution times and the elimination of large matrix storage requirements.
(Author)

A80-20952 * # **Assessment at full scale of exhaust nozzle-to-wing size on STOL-OTW acoustic characteristics.** U. von Glahn and D. Groesbeck (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 98th, Salt Lake City, Utah, Nov. 26-30, 1979, Paper.* 25 p. 5 refs.

On the basis of static zero/acoustic data obtained at model scale, the effect of exhaust nozzle size on flyover noise is evaluated at full scale for different STOL-OTW nozzle configurations. Three types of nozzles are evaluated: a circular/deflector nozzle mounted above the wing, a slot/deflector nozzle mounted on the wing, and a slot nozzle mounted on the wing. The nozzle exhaust plane location, measured from the wing leading edge was varied from 10 to 46 percent of the wing chord (flaps retracted). Flap angles of 20 deg (takeoff) and 60 deg (approach) are included in the study. Initially, perceived noise levels (PNL) are calculated as a function of flyover distance at 152 m altitude. From these plots static EPNL values, defined as flyover relative noise levels, then are obtained as functions of nozzle size for equal aerodynamic performance (lift and thrust). On the basis of these calculations, the acoustic benefits attributable to nozzle size relative to a given wing chord size are assessed.
(Author)

A80-20953 * # **Dispersion of sound in a combustion duct by fuel droplets and soot particles.** J. H. Miles (NASA, Lewis Research Center, Cleveland, Ohio) and D. D. Raftopoulos (Toledo, University, Toledo, Ohio). *Acoustical Society of America, Meeting, 98th, Salt Lake City, Utah, Nov. 26-30, 1979, Paper.* 27 p. 22 refs.

Dispersion and attenuation of acoustic plane wave disturbances propagating in a ducted combustion system are studied. The dispersion and attenuation are caused by fuel droplet and soot emissions from a jet engine combustor. The attenuation and dispersion are due to heat transfer and mass transfer and viscous drag forces between the emissions and the ambient gas. Theoretical calculations show sound propagation at speeds below the isentropic speed of sound at low frequencies. Experimental results are in good agreement with the theory.
(Author)

A80-20956 * # **Reciprocity principle in duct acoustics.** Y.-C. Cho (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 97th, Cambridge, Mass., June 11-15, 1979, Paper.* 21 p. 10 refs.

Various reciprocity relations in duct acoustics have been derived on the basis of the spatial reciprocity principle implied in Green's functions for linear waves. The derivation includes the reciprocity relations between mode conversion coefficients for reflection and transmission in nonuniform ducts, and the relation between the radiation of a mode from an arbitrarily terminated duct and the absorption of an externally incident plane wave by the duct. Such relations are well defined as long as the systems remain linear, regardless of acoustic properties of duct nonuniformities which cause the mode conversions.
(Author)

A80-20964 * # **Comparison of inlet suppressor data with approximate theory based on cutoff ratio.** E. J. Rice and L. J. Heidelberg (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0100.* 26 p. 21 refs.

This paper represents the initial quantitative comparison of inlet suppressor far-field directivity suppression with that predicted using an approximate liner design and evaluation method based upon mode cutoff ratio. The experimental data was obtained using a series of cylindrical point-reacting inlet liners on an Avco-Lycoming YF102 engine. The theoretical prediction program is based upon simplified sound propagation concepts derived from exact calculations. These indicate that all of the controlling phenomenon can be approximately correlated with mode cutoff ratio which itself is intimately related to the angles of propagation within the duct. The objective of the theory-data comparisons is to point out possible deficiencies in the approximate theory which may be corrected. After all theoretical refinements have been made, then empirical corrections can be applied. (Author)

A80-20965 * # **Acoustic considerations of flight effects on jet noise suppressor nozzles.** U. von Glahn (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0164.* 24 p. 14 refs.

Insight into the inflight acoustic characteristics of high-velocity jet noise suppressor nozzles for supersonic cruise aircraft (SCA) is provided. Although the suppression of jet noise over the entire range of directivity angles is of interest, the suppression of the peak noise level in the rear quadrant is frequently of the most interest. Consequently, the paper is directed primarily to the inflight effects at the peak noise level. Both single and inverted-velocity-profile multistream suppressor nozzles are considered. The importance of static spectral shape on the noise reduction due to inflight effects is stressed. (Author)

A80-35496 * # **Spectral structure of pressure measurements made in a combustion duct.** J. H. Miles (NASA, Lewis Research Center, Cleveland, Ohio) and D. D. Raftopoulos (Toledo, University, Toledo, Ohio). *Acoustical Society of America, Meeting, 99th, Atlanta, Ga., Apr. 21-25, 1980, Paper.* 44 p. 43 refs.

The spectral structure of pressure measurements made in a ducted combustion test facility are studied. Dispersion and attenuation of acoustic plane waves may occur in the duct at low frequencies due to combustor emissions and affect the spectral structure. A model that considers the propagation of plane waves through a cloud of particles in a flowing gas and which includes heat transfer between soot particles and the gas is discussed. Experimental results are compared with theory. (Author)

A80-35497 * # **Noise suppression due to annulus shaping of a conventional coaxial nozzle.** U. von Glahn and J. Goodykoontz (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 99th, Atlanta, Ga., Apr. 21-25, 1980, Paper.* 17 p. 5 refs.

Previous studies have shown that increasing the annulus width of a conventional coaxial nozzle with constant bypass velocity will lower the noise level. In the present model-scale study, the annulus was shaped by an eccentric mounting of the annular nozzle with respect to the conical core nozzle. Acoustic measurements were made in the flyover plane below the widest portion of the annulus and at 90 deg and 180 deg from this point. The model-scale spectra are scaled up to engine size (1.07 m diameter) and the perceived noise levels for the eccentric and concentric coaxial nozzles are compared over a limited range of operating conditions. The implications of the acoustic benefits derived from the eccentric nozzle to practical applications are discussed. (Author)

A80-35498 * # **Noise suppression due to annulus shaping of an inverted-velocity-profile coaxial nozzle.** J. Goodykoontz and U. von Glahn (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 99th, Atlanta, Ga., Apr. 21-25, 1980, Paper.* 25 p. 8 refs.

Previous studies have shown that an inverted-velocity-profile coaxial nozzle for use with supersonic cruise aircraft produces less jet noise than an equivalent conical nozzle. Furthermore, decreasing the annulus height (increasing radius ratio with constant flow) results in further noise reduction benefits. In the present model-scale study, the annulus shape, that is, height, was varied by an eccentric mounting of the annular nozzle with respect to a conical core nozzle. Acoustic measurements were made in the flyover plane below the narrowest portion of the annulus and at 90 deg and 180 deg from this point. The model-scale spectra are scaled up to engine size (1.07 m diameter) and the perceived noise levels for the eccentric and baseline concentric inverted-velocity-profile coaxial nozzles are compared over a range of operating conditions. The implications of the acoustic benefits derived with the eccentric nozzle to practical applications are discussed. (Author)

A80-35499 * # **An exploratory survey of noise levels associated with a 100 kW wind turbine.** J. R. Balombin (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 99th, Atlanta, Ga., Apr. 21-25, 1980, Paper.* 18 p.

During performance tests of a 125-foot diameter, 100 kW wind turbine at the NASA Plum Brook Station near Sandusky, Ohio, the opportunity arose to make exploratory noise measurements and results of those surveys are presented. The data include measurements as functions of distance from the turbine, and directivity angle, and cover a frequency range from 1 Hz to several kHz. Potential community impact is discussed in terms of A-weighted noise levels relative to background levels, and the infrasonic spectral content. Finally, the change in the sound power spectrum associated with a change in the rotor speed is described. The acoustic impact of this size wind turbine is judged to be minimal. (Author)

A80-35974 * # **Higher order mode propagation in nonuniform circular ducts.** Y. C. Cho (NASA, Lewis Research Center, Cleveland, Ohio) and K. U. Ingard (MIT, Cambridge, Mass.). *American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 6th, Hartford, Conn., June 4-6, 1980, Paper 80-1018.* 8 p. 10 refs.

This paper presents an analytical investigation of higher order mode propagation in a nonuniform circular duct without mean flow. An approximate wave equation is derived on the assumptions that the duct cross section varies slowly and that mode conversion is negligible. Exact closed form solutions are obtained for a particular class of converging-diverging circular duct which is here referred to as 'circular cosh duct'. Numerical results are presentd in terms of the transmission loss for the various duct shapes and frequencies. The results are applicable to studies of multimodal propagation as well as single mode propagation. The results are also applicable to studies of sound radiation from certain types of contoured inlet ducts, or of sound propagation in a converging-diverging duct of somewhat different shape from a cosh duct. (Author)

A80-35993 * # **Effect of inflow control on inlet noise of a cut-on fan.** R. P. Woodward and F. W. Glaser (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 6th, Hartford, Conn., June 4-6, 1980, Paper 80-1049.* 9 p. 12 refs.

A cut-on, high tip speed fan stage was acoustically tested with three configurations of an inflow control device in the NASA Lewis anechoic chamber. Although this was a cut-on design, rotor-inflow interaction appeared to be a much stronger source of blade passing tone radiated from the inlet than rotor-stator interaction for the 1.6 mean rotor chord separation. Aft external suction applied to the area where the inflow control device joined the inlet produced a further reduction in blade passing tone suggesting that disturbances in the forward flow on the outside of the inlet were superimposed on the inlet boundary layer and were a significant source of tone noise. (Author)

A80-37895 * **Rigorous solutions for sound radiation from circular ducts with hyperbolic horns or infinite plane baffle.** Y. C. Cho (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Sound and Vibration,* vol. 69, Apr. 8, 1980, p. 405-425. 20 refs. Grant No. NGR-09-010-085.

A rigorous treatment is presented of sound radiation from circular ducts with either a hyperbolic horn or an infinite plane baffle. In the analysis hyperboloidal wave functions are used, which are defined here, for the first time, as a class of eigensolutions of the wave equation for oblate spheroidal co-ordinates. The numerical results include the complex conversion (or reflection) coefficients and the radiation directivity for various incident wave modes, spinning modes as well as axisymmetric modes. The solutions are valid for the whole frequency range including frequencies above and below the cut-off frequencies of the duct modes involved. (Author)

A80-41156 * # Workshop report for the AIAA 5th Aeroacoustics Conference. M. E. Goldstein (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Aircraft*, vol. 17, July 1980, p. 473-478.

Summaries of current understandings, technological tools and remaining controversies in the field of aeroacoustics are presented, with attention also given to developments in means of noise suppression to comply with proposed and projected regulations. Topics include jet noise mechanisms and their suppression; turbomachinery noise, including noise sources, noise prediction by the modal approach and experimental methods; duct acoustics, with discussion of sound attenuation and propagation, the application of finite element methods, and the radiation of sound from inlets; helicopter rotor, airplane propeller and V/STOL noise; aircraft interior noise; and general acoustics, atmospheric propagation and the sonic boom. A.L.W.

N80-11870*# Lockheed-Georgia Co., Marietta.
STUDIES OF THE ACOUSTIC TRANSMISSION CHARACTERISTICS OF COAXIAL NOZZLES WITH INVERTED VELOCITY PROFILES, VOLUME 1 Final Report
P. D. Dean, M. Salikuddin, K. K. Ahuja, H. E. Plumblee, and P. Mungur Cleveland, Ohio NASA May 1979 186 p refs
(Contract NAS3-20797)
(NASA-CR-159698; LG79ER0178-Vol-1) Avail: NTIS HC A09/MF A01 CSCL 20A

The efficiency of internal noise radiation through coannular exhaust nozzle with an inverted velocity profile was studied. A preliminary investigation was first undertaken to: (1) define the test parameters which influence the internal noise radiation; (2) develop a test methodology which could realistically be used to examine the effects of the test parameters; (3) and to validate this methodology. The result was the choice of an acoustic impulse as the internal noise source in the in the jet nozzles. Noise transmission characteristics of a nozzle system were then investigated. In particular, the effects of fan nozzle convergence angle, core extention length to annulus height ratio, and flow Mach number and temperatures were studied. The results are presented as normalized directivity plots. R.C.T.

N80-13882*# Hamilton Standard, Windsor Locks, Conn.
ADVANCED TURBO-PROP AIRPLANE INTERIOR NOISE REDUCTION-SOURCE DEFINITION Final Report
B. Magliozzi and Bennett M. Brooks Oct. 1979 90 p refs
(Contract NAS3-20614)
(NASA-CR-159668) Avail: NTIS HC A05/MF A01 CSCL 20A

Acoustic pressure amplitudes and phases were measured in model scale on the surface of a rigid semicylinder mounted in an acoustically treated wind tunnel near a prop-fan (an advanced turboprop with many swept blades) model. Operating conditions during the test simulated those of a prop-fan at 0.8 Mach number cruise. Acoustic pressure amplitude and phase contours were defined on the semicylinder surface. Measurements obtained without the semi-cylinder in place were used to establish the magnitude of pressure doubling for an aircraft fuselage located near a prop-fan. Pressure doubling effects were found to be 6dB at 90 deg incidence decreasing to no effect at grazing incidence. Comparisons of measurements with predictions made using a recently developed prop-fan noise prediction theory which includes linear and non-linear source terms showed good agreement in phase and in peak noise amplitude. Predictions of noise amplitude and phase contours, including pressure doubling effects derived from test, are included for a full scale prop-fan installation. Author

N80-32186*# Lockheed-Georgia Co., Marietta.
A STUDY OF THE TRANSMISSION CHARACTERISTICS OF SUPPRESSOR NOZZLES
K. K. Ahuja, M. Salikuddin, R. H. Burrin, and H. E. Plumbee, Jr. Jun. 1980 263 p refs
(Contract NAS3-20797)
(NASA-CR-165133) Avail: NTIS HC A12/MF A01 CSCL 20A

The internal noise radiation characteristics for a single stream 12 lobe 24 tube suppressor nozzle, and for a dual stream 36 chute suppressor nozzle were investigated. An equivalent single round conical nozzle and an equivalent coannular nozzle system were also tested to provide a reference for the two suppressors. The technique utilized a high voltage spark discharge as a noise source within the test duct which permitted separation of the incident, reflected and transmitted signals in the time domain. These signals were then Fourier transformed to obtain the nozzle transmission coefficient and the power transfer function. These transmission parameters for the 12 lobe, 24 tube suppressor nozzle and the reference conical nozzle are presented as a function of jet Mach number, duct Mach number polar angle and temperature. Effects of simulated forward flight are also considered for this nozzle. For the dual stream, 36 chute suppressor, the transmission parameters are presented as a function of velocity ratios and temperature ratios. Possible data for the equivalent coaxial nozzle is also presented. Jet noise suppression by these nozzles is also discussed. A.R.H.

A80-35951 * # Acoustic behavior of fibrous bulk materials. A. S. Hersh and B. Walker (Hersh Acoustical Engineering, Chatsworth, Calif.). *American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 6th, Hartford, Conn., June 4-6, 1980, Paper 80-0986.* 14 p. 16 refs. Contract No. NAS3-21975.

A semiempirical model of the acoustic behavior of fibrously constructed bulk materials of Hersh and Walker (1979) is generalized to take into account the filtration or removal of particles by fibrous mats and heat conduction between the material fibers and the surrounding fluid. Equations governing the propagation and attenuation of sound waves in a fibrous material are derived on the basis of a solution of the Navier Stokes equation for momentum conservation and a one-dimensional model of heat transfer between the sound field and the fibers. A comparison of the two propagation constants and material impedance specified by the model and experimental measurements for Kevlar 29 indicates the accuracy of the model over a wide range of sound frequencies, material porosities and specimen thickness. It is also found that heat transfer effects are relatively unimportant, while the attenuation constants and material characteristic impedance are a function of fiber orientation relative to sound field propagation direction. A.L.W.

A80-35965 * # Acoustic pressures on a prop-fan aircraft fuselage surface. B. Magliozzi (United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.). *American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 6th, Hartford, Conn., June 4-6, 1980, Paper 80-1002.* 11 p. 9 refs. Contract No. NAS3-20614.

Acoustic pressure amplitude and phase distributions on the surface of a simulated fuselage (a rigid semi-cylinder) installed in an acoustically treated wind tunnel near a Prop-Fan model were measured. The test conditions simulated the relative tip Mach number and blade loading of a full scale Prop-Fan at high altitude 0.8 Mach number cruise. Measurements were also made at equivalent microphone locations without the semi-cylinder to establish the effects of the presence of a fuselage on the sound pressure amplitudes. These effects were found to be 6 dB at 90 degrees incidence, decreasing to no effect at grazing incidence. Comparison of measurements and calculations uisng a Hamilton Standard Prop-Fan noise calculation computer program showed good agreement in peak level and in phase distribution. Continuous recordings were also made of a Prop-Fan RPM sweep at constant simulated flight speed and a simulated flight speed sweep at constant Prop-Fan RPM. These showed smooth variations in noise level over the tip Mach number range 0.878 to 1.143. (Author)

A80-38642 * # **Characteristics of internal- and jet-noise radiation from a multi-lobe, multi-tube suppressor nozzle tested statically and under flight simulation.** K. K. Ahuja, M. Salikuddin, and H. E. Plumblee, Jr. (Lockheed-Georgia Co., Marietta, Ga.). *American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 6th, Hartford, Conn., June 4-6, 1980, Paper 80-1027.* 15 p. 23 refs. Research sponsored by the Lockheed-Georgia Co.; Contract No. NAS3-20797.

Nozzle transmission coefficient (NTC) for a 12-lobe, 24-tube suppressor nozzle and a reference round convergent nozzle of equal area are obtained by an impulse test technique. This technique utilizes a high voltage spark discharge as a noise source within the test duct. Effects of nozzle geometry, jet Mach number, jet temperature and flight velocity on the radiation characteristics of the two nozzles are presented. Likewise, the jet mixing noise measured in the absence of internal noise for both nozzles at static and also simulated flight conditions are discussed. (Author)

A80-45844 * **A comparison of experiment and theory for sound propagation in variable area ducts.** A. H. Nayfeh, J. E. Kaiser, R. L. Marshall, and C. J. Hurst (Virginia Polytechnic Institute and State University, Blacksburg, Va.). *Journal of Sound and Vibration,* vol. 71, July 22, 1980, p. 241-259. 20 refs. Contract No. NAS3-18553.

An experimental and analytical program has been carried out to evaluate sound suppression techniques in ducts that produce refraction effects due to axial velocity gradients. The analytical program employs a computer code based on the method of multiple scales to calculate the influence of axial variations due to slow changes in the cross-sectional area as well as transverse gradients due to the wall boundary layers. Detailed comparisons between the analytical predictions and the experimental measurements have been made. The circumferential variations of pressure amplitudes and phases at several axial positions have been examined in straight and variable area ducts, with hard walls and lined sections, and with and without a mean flow. Reasonable agreement between the theoretical and experimental results has been found. (Author)

72 ATOMIC AND MOLECULAR PHYSICS

Includes atomic structure and molecular spectra

N80-33186* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
HYDROGEN HOLLOW CATHODE ION SOURCE Patent
Michael J. Mirtich, Jr., James S. Sovey, and Robert F. Roman, inventors (to NASA) Issued 19 Aug. 1980 4 p Filed 23 Oct. 1978 Supersedes N79-10894 (17 - 01, p 0118)
(NASA-Case-LEW-12940-1; US-Patent-4,218,633; US-Patent-Appl-SN-953391; US-Patent-Class-313-362; US-Patent-Class-313-231 4) Avail: US Patent and Trademark Office CSCL 20H

A source of hydrogen ions is disclosed and includes a chamber having at one end a cathode which provides electrons and through which hydrogen gas flows into the chamber. Screen and accelerator grids are provided at the other end of the chamber. A baffle plate is disposed between the cathode and the grids and a cylindrical baffle is disposed coaxially with the cathode at the one end of the chamber. The cylindrical baffle is of greater diameter than the baffle plate to provide discharge impedance and also to protect the cathode from ion flux. An anode electrode draws the electrons away from the cathode. The hollow cathode includes a tubular insert of tungsten impregnated with a low work function material to provide ample electrons. A heater is provided around the hollow cathode to initiate electron emission from the low work function material.

Official Gazette of the U.S. Patent and Trademark Office

A80-34048 * **Comments on Auger electron production by Ne/+/ bombardment of surfaces.** S. V. Pepper and J. Ferrante (NASA, Lewis Research Center, Cleveland, Ohio). *Surface Science,* vol. 88, no. 1, Oct. 3, 1979, p. L1-L5. 5 refs.

A80-34049 * **Strengthening of tough iron-12% nickel-reactive metal alloys at 77 K by copper additions.** J. R. Stephens and W. R. Witzke (NASA, Lewis Research Center, Cleveland, Ohio). *Cryog... s,* vol. 20, Jan. 1980, p. 18-24. 13 refs.

75 PLASMA PHYSICS

Includes magnetohydrodynamics and plasma fusion.
For ionospheric plasmas see *46 Geophysics*. For space plasmas see *90 Astrophysics*.

N80-12881*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESULTS OF DUCT AREA RATIO CHANGES IN THE NASA LEWIS H2-O2 COMBUSTION MHD EXPERIMENT
J. Marlin Smith 1979 12 p refs Presented at 18th Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980; sponsored by AIAA
(NASA-TM-79308; E-264) Avail: NTIS HC A02/MF A01 CSCL 20I

MHD power generation experiments utilizing a cesium-seeded H2-O2 working fluid were carried out using a diverging area Hall duct having an entrance Mach number of 2. The experiments were conducted in a high field strength cryomagnet facility at field strengths up to 5 tesla. The effects of power takeoff location, generator loading B field strength, and electrode breakdown voltage were investigated. The effect of area ratio, multiple loading of the duct, and duct location within the magnetic field are considered. R.C.T.

N80-14922*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF VELOCITY OVERSHOOT ON THE PERFORMANCE OF MAGNETOHYDRODYNAMIC SUBSONIC DIFFUSERS
Mahesh S. Greywall (Wichita State Univ.) and J. Marlin Smith 1980 10 p refs Presented at Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980; Sponsored by AIAA
(Contract EF-77-A-01-2674)
(NASA-TM-79305; DOE/NASA/2674-79/6; E-257) Avail: NTIS HC A02/MF A01 CSCL 20I

The evolution of an overshoot velocity distribution was studied in a plane two dimensional diffuser as a function of diffuser divergence angle. The diffuser performance for velocity overshoot was compared to that for a fully developed inlet velocity profile. Results indicate that the ratio of peak-to-center line velocity increases along the diffuser for a diffuser half angle greater than some critical value. It was also found that irrespective of the accompanying inlet temperature distribution, the wall shear stress and the wall heat flux is substantially larger when the inlet velocity profile has an overshoot than that for a fully developed inlet velocity profile. R.C.T.

N80-16885*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMMENTS ON TEC TRENDS
James F. Morris 1979 28 p refs Presented at Intern. Conf. on Plasma Sci., Montreal, 4-6 Jun. 1979; sponsored by IEEE
(NASA-TM-79317; E-273) Avail: NTIS HC A03/MF A01 CSCL 20I

A technology assessment of thermionic energy conversion research and technology is presented. R.E.S.

N80-16886*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTS ON H2-O2MHD POWER GENERATION
J. Marlin Smith 1980 18 p refs Proposed for presentation at the 3d World Hydrogen Energy Conf., Tokyo, 23 - 26 Jun. 1980
(NASA-TM-81424) Avail: NTIS HC A02/MF A01 CSCL 20I

Magnetohydrodynamic power generation experiments utilizing a cesium-seeded H2-O2 working fluid were carried out using a diverging area Hall duct having an entrance Mach number of 2. The experiments were conducted in a high-field strength cryomagnet facility at field strengths up to 5 tesla. The effects of power takeoff location, axial duct location within the magnetic field, generator loading, B-field strength, and electrode breakdown voltage were investigated. For the operating conditions of these experiments, it is found that the power output increases with the square of the B-field and can be limited by choking of the channel or interelectrode voltage breakdown which occurs at Hall fields greater than 50 volts/insulator. Peak power densities of greater than 100 MW/cu M were achieved. A.R.H.

N80-18946*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL RESULTS ON PLASMA INTERACTIONS WITH LARGE SURFACES AT HIGH VOLTAGES
Norman T. Grier 1980 12 p refs Presented at 18th Aerospace Sci. Meeting, Pasadena, Calif., 14-16 Jan. 1980; sponsored by AIAA
(NASA-TM-81423; E-346) Avail: NTIS HC A02/MF A01 CSCL 20I

Multikilowatt power levels for future payloads can be more efficiently generated using solar arrays operating in the kilovolt range. This implies that large areas of the array at high operating voltages will be exposed to the space plasma environment. The resulting interactions of these high voltage surfaces with space plasma environments can seriously impact the performance of the satellite system. The plasma-surface interaction phenomena were studied in tests performed in two separate vacuum chambers, a 4.6 m diameter by 19.2 long chamber and a 20 m diameter by 27.4 m long chamber. The generated plasma density was approximately 1x10 to the 4th power/cu cm. Ten solar array panels, each with areas of 1400 sq cm were used in the tests. Nine of the solar panels were tested as a composite unit in the form of a 3x3 solar panel matrix. The results from all the tests confirmed small sample tests results. Insulators were found to enhance the plasma coupling current for high positive bias and arcing was found to occur at high negative bias. A.R.H.

N80-22083*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POTENTIALITIES OF TEC TOPPING: A SIMPLIFIED VIEW OF PARAMETRIC EFFECTS
James F. Morris 1980 21 p refs Presented at Intern. Conf. on Plasma Sci., Madison, Wisc., 19-21 May 1980; sponsored by IEEE
(Contract EC-77-A-31-1062)
(NASA-TM-81468; DOE/NASA/1062-80/5; E-399) Avail: NTIS HC A02/MF A01 CSCL 10A

An examination of the benefits of thermionic-energy-conversion (TEC)-topped power plants and methods of increasing conversion efficiency are discussed. Reductions in the cost of TEC modules yield direct decreases in the cost of electricity (COE) from TEC-topped central station power plants. Simplified COE, overall-efficiency charts presented illustrate this trend. Additional capital-cost diminution results from designing more compact furnaces with considerably increased heat transfer rates allowable and desirable for high temperature TEC and heat pipes. Such improvements can evolve of the protection from hot corrosion and slag as well as the thermal expansion compatibilities offered by silicon-carbide clads on TEC-heating surfaces. Greater efficiencies and far fewer modules are possible with high-temperature, high-power-density TEC: This decreases capital and fuel costs much more and substantially increases electric power outputs for fixed fuel inputs. In addition to more electricity, less pollution, and lower costs, TEC topping used directly in coal-combustion products contributes balance-of-payment gains. M.G.

N80-33221*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OPTIMAL THERMIONIC ENERGY CONVERSION WITH ESTABLISHED ELECTRODES FOR HIGH-TEMPERATURE TOPPING AND PROCESS HEATING Final Report
James F. Morris Jul. 1980 33 p refs
(Contract EC-77-A-31-1062)
(NASA-TM-81555; DOE/NASA/1062-6; E-514) Avail: NTIS HC A03/MF A01 CSCL 20I

Applied research-and-technology (ART) work reveals that optimal thermionic energy conversion (TEC) with approximately

1000 K to approximately 1100 K collectors is possible using well established tungsten electrodes. Such TEC with 1800 K emitters could approach 26.6% efficiency at 27.4 W/sq cm with approximately 1000 K collectors and 21.7% at 22.6 W/sq cm with approximately 1100 K collectors. These performances require 1.5 and 1.7 eV collector work functions (not the 1 eV ultimate) with nearly negligible interelectrode losses. Such collectors correspond to tungsten electrode systems in approximately 0.9 to approximately 6 torr cesium pressures with 1600 K to 1900 K emitters. Because higher heat-rejection temperatures for TEC allow greater collector work functions, interelectrode loss reduction becomes an increasingly important target for applications aimed at elevated temperatures. Studies of intragap modifications and new electrodes that will allow better electron emission and collection with lower cesium pressures are among the TEC-ART approaches to reduced interelectrode losses. These solutions will provide very effective TEC to serve directly in coal-combustion products for high-temperature topping and process heating. In turn this will help to use coal and to use it well. A.R.H.

A80-11366 * **Study of a rare-gas transverse fast discharge.** D. L. Chubb and C. J. Michels (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Applied Physics*, vol. 50, Oct. 1979, p. 6230-6240. 34 refs.

An experimental and analytical study of a Blumlein-type transverse fast discharge operating with He and Xe are presented. An electro-optical voltage probe was used to measure the discharge voltage, and the measured voltages were in agreement with the computed voltages. The analytical model was used to predict the dependence of the discharge efficiency for producing metastables and ions on the important plasma and external circuit parameters. In He the ion efficiency is greater than the metastable efficiency, while in Xe it is the opposite; the He ion efficiencies are much larger than in Xe, while Xe metastable efficiencies are much larger than in He. These differences between Xe and He are accounted by the large dissociative recombination rate of Xe compared with He. A.T.

A80-18243 * # **Results of duct area ratio changes in the NASA Lewis H2-O2 combustion MHD experiment.** J. M. Smith (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0023.* 7 p.

MHD power generation experiments utilizing a cesium-seeded H2-O2 working fluid have been carried out using a diverging area Hall duct having an entrance Mach number of 2. The experiments are conducted in a high-field strength cryomagnet facility at field strengths up to 5 tesla. The effects of power takeoff location, generator loading, B-field strength, and electrode breakdown voltage have been investigated. In this paper the effect of area ratio, multiple loading of the duct, and duct location within the magnetic field are considered. (Author)

A80-25476 * **The effect of a weak vertical magnetic field on fluctuation-induced transport in a Bumpy-Torus plasma.** Y. C. Kim, E. J. Powers, J. Y. Hong (Texas, University, Austin, Tex.), J. R. Roth, and W. M. Krawczonek (NASA, Lewis Research Center, Cleveland, Ohio). *Nuclear Fusion*, vol. 20, Feb. 1980, p. 171-176. 11 refs. Research supported by the Texas Atomic Energy Research Foundation; Grant No. NsG-3089.

A80-44239 * # **Experiments on H2-O2 MHD power generation.** J. M. Smith (NASA, Lewis Research Center, Cleveland, Ohio). *International Association for Hydrogen Energy, World Hydrogen Energy Conference, 3rd, Tokyo, Japan, June 23-26, 1980, Paper.* 16 p.

MHD power generation experiments utilizing a cesium-seeded H2-O2 working fluid have been carried out using a diverging area Hall duct having an entrance Mach number of 2. The experiments are conducted in a high-field strength cryomagnet facility at field strengths up to 5 tesla. The effects of power takeoff location, axial duct location within the magnetic field, generator loading, B field strength, and electrode breakdown voltage were investigated. For the operating conditions of these experiments it is found that the power output increases with the square of the B field and can be limited by choking of the channel or interelectrode voltage breakdown which occurs at Hall fields greater than 50 volts/insulator. (Author)

A80-46265 * **Parametric dependence of ion temperature and electron density in the SUMMA hot-ion plasma using laser light scattering and emission spectroscopy.** A. Snyder, R. W. Patch, and M. R. Lauver (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Quantitative Spectroscopy and Radiative Transfer*, vol. 24, Aug. 1980, p. 167-177. 16 refs.

Hot-ion plasma experiments were conducted in the NASA Lewis SUMMA facility. A steady-state modified Penning discharge was formed by applying a radially inward dc electric field of several kilovolts near the magnetic mirror maxima. Results are reported for a hydrogen plasma covering a wide range in midplane magnetic flux densities from 0.5 to 3.37 T. Input power greater than 45 kW was obtained with water-cooled cathodes. Steady-state plasmas with ion kinetic temperatures from 18 to 830 eV were produced and measured spectroscopically. These ion temperatures were correlated with current, voltage, and magnetic flux density as the independent variables. Electron density measurements were made using an unusually sensitive Thomson scattering apparatus. The measured electron densities range from 2.1 x 10 to the 11th to 6.8 x 10 to the 12th per cu cm. (Author)

N80-12880*# State Univ. of New York at Buffalo. Lab. for Power and Environmental Studies.
EXPERIMENTAL AND THEORETICAL INVESTIGATION FOR THE SUPPRESSION OF THE PLANAR ARC DROP IN THE THERMIONIC CONVERTER Final Report, 1 Jul. 1974 - 15 Apr. 1978
David T. Shaw Apr. 1979 41 p refs
(Grant NsG-7071)
(NASA-CR-159611; LAPES-79-003) Avail: NTIS HC A03/MF A01 CSCL 20I

The possibility of using N2 as a gas additive for the development of thermionic topping generators was investigated. The experiment is described and observations are discussed. The potential of applying microwave power in the interelectrode spacing of the converter as an ion generation source was also assessed. A.R.H.

N80-14923*# Colorado State Univ., Fort Collins. Dept. of Physics.
INTERACTION OF HIGH VOLTAGE SURFACES WITH THE SPACE PLASMA Annual Report
Harold R. Kaufman and Raymond S. Robinson May 1979 81 p refs
(Grant NsG-3196)
(NASA-CR-159731) Avail: NTIS HC A05/MF A01 CSCL 20I

Tests were conducted using plasma densities of approximately 10 to the 5th power - 10 to the 6th power/cu cm. Insulating materials tested were polyimide (Dapton), mica and glass. Surface-area effects were found to be substantially reduced from those previously reported at lower plasma densities. The difference in typical plasma density was felt to be the major cause of this change, although a saturation effect may also be involved. At the 10 to the 5th power/cu cm plasma density range, surface effects on collection current appear limited to roughly 1 cm from the hole. A factor of several reduction of collected current was obtained with both surface scribing and a 2 x 2 cm conducting mesh. It appears possible that the effects of surface treatment might be more significant at lower plasma densities. Effects of repeated tests were also noted, with current collection decreasing with successive tests. Depending on the materials involved, the effect appeared due to either the smoothing of the inside of the insulator hole or the sputtering of insulator on the exposed conductor. A general conclusion was made from a variety of observations, that the generation of vapor is a major factor in the enhancement of collected current. A.R.H.

N80-26161*# Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering.

ION EXTRACTION FROM A PLASMA Ph.D. Thesis. Progress Report, 1 Dec. 1979 - 1 Dec. 1980

Graeme Aston Jun. 1980 93 p refs

(Grant NGR-06-002-112)

(NASA-CR-159849) Avail: NTIS HC A05/MF A01 CSCL 20I

An experimental investigation of the physical processes governing ion extraction from a plasma is presented. The screen hole plasma sheath of a multiaperture ion accelerator system is defined by equipotential plots for a variety of accelerator system geometries and operating conditions. A sheath thickness of at least fifteen Debye lengths is shown to be typical. The electron density variation within the sheath satisfies a Maxwell Boltzmann density distribution at an effective electron temperature dependent on the discharge plasma primary to Maxwellian electron density ratio. Plasma ion flow up to and through the sheath is predominately one dimensional and the ions enter the sheath with a modified Bohm velocity. Low values of the screen grid thickness to screen hole diameter ratio give good ion focusing and high extracted ion currents because of the effect of screen webbing on ion focusing. Author

N80-27189*# Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering.

PLASMA PHYSICS ANALYSIS OF SERT-2 OPERATION

Harold R. Kaufman Jan. 1980 59 p refs

(Grant NsG-3011)

(NASA-CR-159814) Avail: NTIS HC A04/MF A01 CSCL 20I

An analysis of the major plasma processes involved in the SERT 2 spacecraft experiments was conducted to aid in the interpretation of recent data. A plume penetration model was developed for neutralization electron conduction to the ion beam and showed qualitative agreement with flight data. In the SERT 2 configuration conduction of neutralization electrons between thrusters was experimentally demonstrated in space. The analysis of this configuration suggests that the relative orientation of the two magnetic fields was an important factor in the observed results. Specifically, the opposed field orientation appeared to provide a high conductivity channel between thrusters and a barrier to the ambient low energy electrons in space. The SERT 2 neutralizer currents with negative neutralizer biases were up to about twice the theoretical prediction for electron collection by the ground screen. An explanation for the higher experimental values was a possible conductive path from the neutralizer plume to a nearby part of the ground screen. Plasma probe measurements of SERT 2 gave the clearest indication of plasma electron temperature, with normal operation being near 5 eV and discharge only operation near 2 eV. E.D.K.

N80-32223*# Colorado State Univ., Fort Collins. Dept. of Physics.

INTERACTION OF HIGH VOLTAGE SURFACES WITH THE SPACE PLASMA Annual Report

Harold R. Kaufman and Raymond S. Robinson May 1980 50 p refs

(Grant NsG-3196)

(NASA-CR-165131) Avail: NTIS HC A03/MF A01 CSCL 20I

High voltage solar arrays provide spacecraft power while optimizing mass and power efficiency. Operating such arrays in the space plasma environment can result in anomalously large currents being collected through insulation defects. Two thicknesses of the insulating material were tested, with no effect found due to insulator thickness. In these tests the polyimide thickness was always much less than the pinhole diameter. The pinhole area was varied over an area range of more than 30:1. It was found that the current collected was independent of the pinhole area for hole diameters from 0.35 to 2.0 mm. Two types of adhesives were tried in two different configurations. The adhesives were chosen for their extreme difference in vacuum qualifications. Neither adhesive types nor configuration made a significant difference in current collection. The temperature of the insulating material was also varied. It was found that current collection decreased with increasing temperature. Tests were conducted to see if pinhole current collection decreased with time, as was indicated by the effects of several short tests. Current was collected for over four hours while the conductor potential was held constant at 1000 volts. A smooth decrease with time was not observed, but rather a roughly constant current collection with brief surges to high values. Tests were also conducted with the simulated solar cell biased negative. The current was found to be proportional to pinhole area. R.K.G.

76 SOLID-STATE PHYSICS

Includes superconductivity.

For related information, see also *33 Electronics and Electrical Engineering* and *36 Lasers and Masers*.

N80-16914*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PLANAR MULTIJUNCTION HIGH VOLTAGE SOLAR CELLS

John C. Evans, Jr., An-Ti Chai, and Chandra Goradia (Cleveland State Univ., Ohio) 1980 10 p refs Presented at 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan 1980; sponsored by IEEE

(NASA-TM-81389, E-299) Avail NTIS HC A02/MF A01 CSCL 20L

Technical considerations, preliminary results, and fabrication details are discussed for a family of high-voltage planar multijunction (PMJ) solar cells which combine the attractive features of planar cells with conventional or interdigitated back contacts and the vertical multijunction (VMJ) solar cell. The PMJ solar cell is internally divided into many voltage-generating regions, called unit cells, which are internally connected in series. The key to obtaining reasonable performance from this device was the separation of top surface field regions over each active unit cell. Using existing solar cell fabricating methods, output voltages in excess of 20 volts per linear centimeter are possible. Analysis of the new device is complex, and numerous geometries are being studied which should provide substantial benefits in both normal sunlight usage as well as with concentrators. A.R.H.

N80-23180*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RADIATION DAMAGE IN HIGH VOLTAGE SILICON SOLAR CELLS

Irving Weinberg, Henry Brandhorst, Jr., Clifford K. Swartz, and Victor G. Weizer 1980 11 p refs Presented at 2nd European Symp. on Photovoltaic Generators in Space, Heidelberg, 15-17 Apr 1980

(NASA-TM-81478, E-412) Avail NTIS HC A02/MF A01 CSCL 20L

Three high open-circuit voltage cell designs based on 0.1 ohm-cm p-type silicon were irradiated with 1 MeV electrons and their performance determined to fluences as high as 10 to the 15th power/sq cm. Of the three cell designs, radiation induced degradation was greatest in the high-low emitter (HLE cell). The diffused and ion implanted cells degraded approximately equally but less than the HLE cell. Degradation was greatest in an HLE cell exposed to X-rays before electron irradiation. The cell regions controlling both short-circuit current and open-circuit voltage degradation were defined in all three cell types. An increase in front surface recombination velocity accompanied time dependent degradation of an HLE cell after X-irradiation. It was speculated that this was indirectly due to a decrease in positive charge at the silicon-oxide interface. Modifications aimed at reducing radiation induced degradation are proposed for all three cell types. Author

N80-26182*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE PLANAR MULTIJUNCTION CELL: A NEW SOLAR CELL FOR EARTH AND SPACE

John C. Evans, An-Ti Chai, and Chandra Goradia 1980 8 p refs Proposed for presentation at 15th Intern. Energy Conversion Engr. Conf., Seattle, Wash., 18-22 Aug. 1980; sponsored by AIAA, presented at 14th IEEE Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980

(NASA-TM-81526) Avail: NTIS HC A02/MF A01 CSCL 20L

A family of high-voltage solar cells, called the planar multijunction (PMJ) cell is being developed. The new cells combine the attractive features of planar cells with conventional or interdigitated back contacts and the vertical multijunction solar cell. The PMJ solar cell is internally divided into many voltage-generating regions, called unit cells, which are internally connected in series. The key to obtaining reasonable performance from this device was the separation of top surface field regions over each active unit cell area. Using existing solar cell fabricating methods, output voltages in excess of 20 volts per linear centimeter are possible. Analysis of the new device is complex, and numerous geometries are being studied which should provide substantial benefits in both normal sunlight usage as well as with concentrators. Author

A80-16843 * **Hyperfine magnetic field at Cd impurity site in L2/1/ Heusler alloys Rh2MnGe and Rh2MnPb by TDPAC technique.** S. Jha (Cincinnati, University, Cincinnati, Ohio), R. D. Black, G. M. Julian (Miami University, Oxford, Ohio), J. W. Blue, and D. C. Liu (NASA, Lewis Research Center, Cleveland, Ohio). *(Institute of Electrical and Electronics Engineers and American Institute of Physics, Joint International Magnetics Conference and Conference on Magnetism and Magnetic Materials, 2nd, New York, N.Y., July 17-20, 1979.) Journal of Applied Physics*, vol. 50, Nov. 1979, pt. 2, p. 7507-7509. Grant No. NsG-3091.

A80-21120 * # **Some dynamic and time-averaged flow measurements in a turbine rig.** L. N. Krause and G. C. Fralick (NASA, Lewis Research Center, Cleveland, Ohio). *ASME, Transactions, Journal of Engineering for Power*, vol. 102, Jan. 1980, p. 223, 224. 5 refs.

Four types of sensors were used to make both dynamic and time-averaged flow measurements in a cold turbine rig to determine the magnitude of errors in time-averaged total-pressure measurement at a station 5 1/2 blade cords downstream from the rotor. The errors turned out to be negligible. The sensors and their intended use are discussed. (Author)

A80-22250 * **Anodic polarization behavior of austenitic stainless steel alloys with lower chromium content.** W. Y. C. Chen (Purdue University, Hammond, Ind.) and J. R. Stephens (NASA, Lewis Research Center, Cleveland, Ohio). *Corrosion*, vol. 35, Oct. 1979, p. 443-451. 17 refs.

A80-22300 * **Effect of interfacial species on shear strength of metal-sapphire contacts.** S. V. Pepper (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Applied Physics*, vol. 50, Dec. 1979, p. 8062-8065. 26 refs.

The interfacial shear strength of the metal-insulator system has been studied by means of the coefficient of static friction of copper, nickel, or gold contacts on sapphire in ultrahigh vacuum. The effect on contact strength of adsorbed oxygen, nitrogen, chlorine, and carbon monoxide on the metal surfaces is reported. It was found that exposures as low as 1 L of O2 on Ni produced observable increases in contact strength, whereas exposures of 3 L of Cl2 lead to a decrease in contact strength. These results imply that submonolayer concentrations of these species at the interface of a thin Ni film on Al2O3 should affect film adhesion similarly. The atomic mechanism by which these surface or interface phases affect interfacial strength is not yet understood. (Author)

A80-26007 * # **Homogeneous alignment of nematic liquid crystals by ion beam etched surfaces.** E. G. Wintucky (NASA, Lewis Research Center, Cleveland, Ohio), R. Mahmood, and D. L. Johnson (Kent State University, Kent, Ohio). *Electrochemical Society, Meeting, 156th, Los Angeles, Calif., Oct. 15-19, 1979, Paper.* 17 p. 7 refs.

A wide range of the ion beam etch parameters are capable of producing uniform homogeneous alignment of nematic liquid crystals on SiO2 films. The alignment surfaces were generated by obliquely incident argon ions; a smaller range of ion beam parameters was also investigated with ZrO2 films and found suitable for homogeneous alignment. Extinction ratios were very high, and twist and tilt-bias angles were very small. The SEM results indicate a parallel oriented surface structure on the ion beam etched surfaces which may determine alignment. (Author)

A80-33853 * **Critical currents in A-15 structure Nb3Al converted from cold-worked bcc structure.** J. A. Woollam, S. A. Alterovitz, E. Haugland (NASA, Lewis Research Center, Cleveland, Ohio), and G. W. Webb (California, University, La Jolla, Calif.). *Applied Physics Letters,* vol. 36, Apr. 15, 1980, p. 706-708. 12 refs. NASA-NSF-supported research.

The paper considers critical currents in A-15 structure Nb3Al converted from a cold-worked bcc structure. Nb3Al prepared in the ductile phase by quenching and mechanical working followed by conversion to the A-15 structure could carry currents above 10 to the 9th power A/sq m in fields near 20 T. These critical currents are comparable to those of Nb3Ge and V3Ga which are closest competing materials for use in high fields; further enhancement of the critical current is possible if thermal treatments are optimized. A.T.

A80-44234 * // **Radiation damage in high voltage silicon solar cells.** I. Weinberg, H. W. Brandhorst, Jr., C. K. Swartz, and V. G. Welzer (NASA, Lewis Research Center, Cleveland, Ohio). *European Space Agency and Deutsche Gesellschaft für Luft- und Raumfahrt, European Symposium on Photovoltaic Generators in Space, 2nd, Heidelberg, West Germany, Apr. 15-17, 1980, Paper.* 9 p. 12 refs.

Three high open-circuit voltage cell designs based on 0.1 ohm-cm p-type silicon were irradiated with 1 MeV electrons and their performance determined to fluences as high as 10 to the 15th/sq cm. Of the three cell designs, radiation induced degradation was greatest in the high-low emitter (HLE) cell. The diffused and ion implanted cells degraded approximately equally but less than the HLE cell. Degradation was greatest in an HLE cell exposed to X-rays before electron irradiation. The cell regions controlling both short-circuit current and open-circuit voltage degradation were defined in all three cell types. An increase in front surface recombination velocity accompanied time dependent degradation of a HLE cell after X-irradiation. It was speculated that this was indirectly due to a decrease in positive charge at the silicon-oxide interface. Modifications aimed at reducing radiation induced degradation are proposed for all three cell types. (Author)

A80-19776 * **Negative streamer development in FEP teflon.** B. L. Beers, V. W. Pine, H. C. Hwang, and H. W. Bloomberg (Science Applications, Inc., Radiation and Electromagnetics Div., Vienna, Va.). *(IEEE, U.S. Defense Nuclear Agency, and Jet Propulsion Laboratory, Annual Conference on Nuclear and Space Radiation Effects, 16th, Santa Cruz, Calif., July 17-20, 1979.) IEEE Transactions on Nuclear Science,* vol. NS-26, Dec. 1979, p. 5127-5133. 12 refs. Contract No. NAS3-21378.

A computational model is developed which describes the evolution and propagation of an ionizing front (negative streamer) in solid materials. The ionization front consists of drifting avalanching electrons moving self-consistently under the influence of their own space-charge field together with an applied external field. The required input information for the model consists of the functional dependence of the macroscopic transport coefficients on the local electric field, the initial conditions for beginning the calculation, and the strength of the applied field. A computational approach for specifying the transport coefficients and initional conditions is also described. The approach has been implemented by constructing three computer codes which sequentially interface, beginning with single electron scattering, and ending with streamer development. Computational results are presented for model calculations in Teflon. The overall model is perceived to provide a picture of the initiation phase of a propagating discharge in electron-irradiated dielectrics. (Author)

77 THERMODYNAMICS AND STATISTICAL PHYSICS

Includes quantum mechanics, and Bose and Fermi statistics

For related information see also *25 Inorganic and Physical Chemistry* and *34 Fluid Mechanics and Heat Transfer*.

A80-18630 * # **Thermophysical property data - Who needs them.** R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Dec. 2-7, 1979, Paper 79-WA/HT-17.* 9 p. 72 refs. Members, $1.50; nonmembers, $3.00.

Specific examples are cited herein to illustrate the universal needs and demands for thermophysical property data. Applications of the principle of similarity in fluid mechanics and heat transfer and extensions of the principle to fluid mixtures are discussed. It becomes quite clear that no matter how eloquent theories or experiments in fluid mechanics or heat transfer are, the results of their application can be no more accurate than the thermophysical properties required to transform these theories into practice, or in the case of an experiment, to reduce the data. Present-day projects take place on such a scale that the need for international standards and mutual cooperation is evident. (Author)

81 ADMINISTRATION AND MANAGEMENT

Includes management planning and research.

N80-24200*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MATRIX MANAGEMENT FOR AEROSPACE 2000
John F. McCarthy, Jr. May 1980 16 p refs Presented at the Intern. Meeting and Techn. Display: Global Technol. 2000, Baltimore, 5-11 May 1980
(NASA-TM-81509; E-447) Avail: NTIS HC A02/MF A01 CSCL 05A

The matrix management approach to program management is an organized effort for attaining program objectives by defining and structuring all elements so as to form a single system whose parts are united by interaction. The objective of the systems approach is uncompromisingly complete coverage of the program management endeavor. Starting with an analysis of the functions necessary to carry out a given program, a model must be defined; a matrix of responsibility assignment must be prepared; and each operational process must be examined to establish how it is to be carried out and how it relates to all other processes.
A.R.H.

A80-40700 * # **Matrix management for aerospace 2000.** J. F. McCarthy, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, International Meeting and Technical Display on Global Technology 2000, Baltimore, Md., May 6-8, 1980, Paper 80-0946.* 14 p. 8 refs.

The matrix management approach to program management is described, showing that it is an organized approach to attaining program objectives by defining and structuring all elements so as to form a single system whose parts are united by interaction. The objective of the systems approach is to attain an uncompromised complete coverage of the program management effort. It is demonstrated that beginning with an analysis of the functions necessary to carry out a given program, a model must be defined; a matrix of responsibility assignment must be prepared; and each operational process is examined to establish how it is to be implemented and how it relates to all other processes.
M.E.P.

83 ECONOMICS AND COST ANALYSIS

Includes cost effectiveness studies.

N80-11950*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COST-EFFECTIVE TECHNOLOGY ADVANCEMENT DIRECTIONS FOR ELECTRIC PROPULSION TRANSPORTATION SYSTEMS IN EARTH-ORBITAL MISSIONS

John D. Regetz, Jr. and C. H. Terwilliger (Boeing Aerospace Co., Seattle, Wash.) 1979 21 p ref Presented at the Fourteenth Intern. Conf. on Electric Propulsion, Princeton, N. J., 30 Oct. - 1 Nov. 1979, sponsored by AIAA and Deut. Ges. fur Luft und Raumfahrt
(NASA-TM-79289) Avail: NTIS HC A02/MF A01 CSCL 05C

The directions that electric propulsion technology should take to meet the primary propulsion requirements for earth-orbital missions in the most cost effective manner are determined. The mission set requirements, state of the art electric propulsion technology and the baseline system characterized by it, adequacy of the baseline system to meet the mission set requirements, cost optimum electric propulsion system characteristics for the mission set, and sensitivities of mission costs and design points to system level electric propulsion parameters are discussed. The impact on overall costs than specific masses or costs of propulsion and power systems is evaluated. A.W.H.

85 URBAN TECHNOLOGY AND TRANSPORTATION

Includes applications of space technology to urban problems; technology transfer; technology assessment; and surface and mass transportation.

For related information see *03 Air Transportation and Safety, 16 Space Transportation,* and *44 Energy Production and Conversion.*

N80-21200*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUPPORTING RESEARCH AND TECHNOLOGY FOR AUTOMOTIVE STIRLING ENGINE DEVELOPMENT
William A. Tomazic 1980 20 p Presented at 5th Intern. Automotive Propulsion System Symp., Dearborn, Mich., 14-18 Apr. 1980
(NASA-TM-81495; E-400; DOE/NASA/1040-80/13) Avail: NTIS HC A02/MF A01 CSCL 13F

The technology advancement topics described are a part of the supporting research and technology (SRT) program conducted to support the major Stirling engine development program. This support focuses on developing alternatives or backups to the engine development in critical areas. These areas are materials, seals control, combustors and system analysis. Specific objectives and planned milestone schedules for future activities as now envisioned are described. These planned SRT activities are related to the timeline of the engine development program that they must support. A.M.S.

N80-21201*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FUEL ECONOMY SCREENING STUDY OF ADVANCED AUTOMOTIVE GAS TURBINE ENGINES
John L. Klann Mar. 1980 57 p
(Contract EC-77-A-31-1040)
(NASA-TM-81433; E-357; DOE/NASA/1040-80/11) Avail: NTIS HC A04/MF A01 CSCL 13F

Fuel economy potentials were calculated and compared among ten turbomachinery configurations. All gas turbine engines were evaluated with a continuously variable transmission in a 1978 compact car. A reference fuel economy was calculated for the car with its conventional spark ignition piston engine and three speed automatic transmission. Two promising engine/transmission combinations, using gasoline, had 55 to 60 percent gains over the reference fuel economy. Fuel economy sensitivities to engine design parameter changes were also calculated for these two combinations. Author

N80-28254*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY RESULTS OF STEADY STATE CHARACTERIZATION OF NEAR TERM ELECTRIC VEHICLE BREADBOARD PROPULSION SYSTEM
Noel B. Sargent Jul. 1980 10 p
(Contract EC-77-A-31-1011)
(NASA-TM-81546; DOE/NASA/1011-31; E-502) Avail: NTIS HC A02/MF A01 CSCL 13F

The steady state test results on a breadboard version of the General Electric Near Term Electric Vehicle (ETV-1) are discussed. The breadboard was built using exact duplicate vehicle propulsion system components with few exceptions. Full instrumentation was provided to measure individual component efficiencies. Tests were conducted on a 50 hp dynamometer in a road load simulator facility. Characterization of the propulsion system over the lower half of the speed-torque operating range has shown the system efficiency to be composed of a predominant motor loss plus a speed dependent transaxle loss. At the lower speeds with normal road loads the armature chopper loss is also a significant factor. At the conditions corresponding to a cycle for which the vehicle system was specifically designed, the efficiencies are near optimum. M.G.

N80-30229*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A LABORATORY FACILITY FOR ELECTRIC VEHICLE PROPULSION SYSTEM TESTING
Noel B. Sargent 1980 11 p refs Presented at Intern. Congr. of Transportation, Dearborn, Mich., 15-17 Sep. 1980; sponsored in cooperation with Vehicle Technology Society and IEEE, Society of Automotive Engineers, and Inst. of Electrical Engineers
(NASA-TM-81574; DOE/NASA/1011-32; E-544) Avail: NTIS HC A02/MF A01 CSCL 13F

The road load simulator facility located at the NASA Lewis Research Center enables a propulsion system or any of its components to be evaluated under a realistic vehicle inertia and road loads. The load is applied to the system under test according to the road load equation: F(net) = K1F1 + K2F2V + K3 sin V + K4(dv/dt) + K5 sin theta. The coefficient of each term in the equation can be varied over a wide range with vehicle inertial representative of vehicles up to 7500 pounds simulated by means of flywheels. The required torque is applied by the flywheels, a hydroviscous absorber and clutch, and a drive motor integrated by a closed loop control system to produce a smooth, continuous load up to 150 horsepower. A.R.H.

A80-14841 * **A new traffic control design method for large networks with signalized intersections.** G. G. Leininger, D. C. Colony (Toledo, University, Toledo, Ohio), and K. Seldner (NASA, Lewis Research Center, Cleveland, Ohio). In: A link between science and applications of automatic control; Proceedings of the Seventh Triennial World Congress, Helsinki, Finland, June 12-16, 1978. Volume 2. (A80-14794 03-63) Oxford and New York, Pergamon Press, 1979, p. 1567-1573. 9 refs.

The paper presents a traffic control design technique for application to large traffic networks with signalized intersections. It is shown that the design method adopts a macroscopic viewpoint to establish a new traffic modelling procedure in which vehicle platoons are subdivided into main stream queues and turning queues. Optimization of the signal splits minimizes queue lengths in the steady state condition and improves traffic flow conditions, from the viewpoint of the traveling public. Finally, an application of the design method to a traffic network with thirty-three signalized intersections is used to demonstrate the effectiveness of the proposed technique. M.E.P.

N80-13989*# Mechanical Technology, Inc., Latham, N. Y. Stirling Engine Systems Div.
ASSESSMENT OF THE STATE OF TECHNOLOGY OF AUTOMOTIVE STIRLING ENGINES
Sep. 1979 329 p refs
(Contracts DEN3-32; EC-77-A-31-10040)
(NASA-CR-159631; DOE/NASA/0032-79/4; MTI-79ASE77RE2) Avail: NTIS HC A15/MF A01 CSCL 13F

The current status of automotive Stirling engine technology is considered. The energy is described and the history of its evolution is reviewed. Overall engine, component, subsystem and material problem areas are identified and recommendations are made for further development and testing. Potential improvements are also identified. Projected Stirling engine/vehicle performance is compared to that of vehicles using current internal combustion engine in terms of performance, fuel consumption, multifuel capability, emissions, and noise level. It is concluded that the potential for achieving 1984 program goals is clearly discernible. The program goals require at least a 30 percent reduction in fuel consumption, acceptable emissions, and the capability of satisfactorily operating with a variety of alternate fuels. A.R.H.

N80-17916*# Garrett Corp., Torrance, Calif.
ADVANCED ELECTRIC PROPULSION SYSTEM CONCEPT FOR ELECTRIC VEHICLES
A. E. Raynard and F. E. Forbes Aug. 1979 157 p refs
(Contracts EC-77-A-31-1044; DEN3-81)
(NASA-CR-159651; DOE/NASA/0081-79/1;

AiResearch 79-16182) Avail NTIS HC A08/MF A01 CSCL 13F

Seventeen propulsion system concepts for electric vehicles were compared to determine the differences in components and battery pack to achieve the basic performance level. Design tradeoffs were made for selected configurations to find the optimum component characteristics required to meet all performance goals. The anticipated performance when using nickel-zinc batteries rather than the standard lead-acid batteries was also evaluated. The two systems selected for the final conceptual design studies included a system with a flywheel energy storage unit and a basic system that did not have a flywheel. The flywheel system meets the range requirement with either lead-acid or nickel-zinc batteries and also the acceleration of zero to 89 km/hr in 15 s. The basic system can also meet the required performance with a fully charged battery, but, when the battery approaches 20 to 30 percent depth of discharge, maximum acceleration capability gradually degrades. The flywheel system has an estimated life-cycle cost of $0.041/km using lead-acid batteries. The basic system has a life-cycle cost of $0.06/km. The basic system, using batteries meeting ISOA goals, would have a life-cycle cost of $0.043/km. A.R.H.

N80-18991*# Brobeck (William M.) and Associates, Berkeley, Calif.

STUDY OF ADVANCED ELECTRIC PROPULSION SYSTEM CONCEPT USING A FLYWHEEL FOR ELECTRIC VEHICLES Final Report

Francis C. Younger and Heinz Lackner Dec. 1979 231 p refs
(Contracts DEN3-78; EC-77-A-31-1011)
(NASA-CR-159650; DOE/NASA/0078-79/1;
WMB/A-4500-131-3-R1) Avail: NTIS HC A11/MF A01 CSCL 10B

Advanced electric propulsion system concepts with flywheels for electric vehicles are evaluated and it is predicted that advanced systems can provide considerable performance improvement over existing electric propulsion systems with little or no cost penalty. Using components specifically designed for an integrated electric propulsion system avoids the compromises that frequently lead to a loss of efficiency and to inefficient utilization of space and weight. A propulsion system using a flywheel power energy storage device can provide excellent acceleration under adverse conditions of battery degradation due either to very low temperatures or high degrees of discharge. Both electrical and mechanical means of transfer of energy to and from the flywheel appear attractive; however, development work is required to establish the safe limits of speed and energy storage for advanced flywheel designs and to achieve the optimum efficiency of energy transfer. Brushless traction motor designs using either electronic commutation schemes or dc-to-ac inverters appear to provide a practical approach to a mass producible motor, with excellent efficiency and light weight. No comparisons were made with advanced system concepts which do not incorporate a flywheel. M.G.

N80-18992*# Brobeck (William M.) and Associates, Berkeley, Calif.

AN AUTOMATICALLY-SHIFTED TWO-SPEED TRANSAXLE SYSTEM FOR AN ELECTRIC VEHICLE Final Report, Dec. 1978 - Dec. 1979

Hayden S. Gordon and Gregory V. Hassman Jan. 1980 34 p refs
(Contracts DEN3-84; EC-77-A-31-1044)
(NASA-CR-159746; DOE/NASA/0084-79/1;
WMB/A-131-4-R2) Avail: NTIS HC A03/MF A01 CSCL 13F

An automatic shifting scheme for a two speed transaxle for use with an electric vehicle propulsion system is described. The transaxle system was to be installed in an instrumented laboratory propulsion system of an ac electric vehicle drive train. The transaxle which had been fabricated is also described. J.M.S.

N80-21202*# Cleveland State Univ., Ohio.

ERROR ANALYSIS IN THE MEASUREMENT OF AVERAGE POWER WITH APPLICATION TO SWITCHING CONTROLLERS Contractor Report, Oct. 1978 - Oct. 1979

James E. Maisel Mar. 1980 84 p refs Sponsored by NASA
(Contract EC-77-A-31-1044)
(NASA-CR-159792; DOE/NASA/3222-80/1) Avail: NTIS HC A05/MF A01 CSCL 10B

Power measurement errors due to the bandwidth of a power meter and the sampling of the input voltage and current of a power meter were investigated assuming sinusoidal excitation and periodic signals generated by a model of a simple chopper system. Errors incurred in measuring power using a microcomputer with limited data storage were also considered. The behavior of the power measurement error due to the frequency responses of first order transfer functions between the input sinusoidal voltage, input sinusoidal current, and the signal multiplier was studied. Results indicate that this power measurement error can be minimized if the frequency responses of the first order transfer functions are identical. The power error analysis was extended to include the power measurement error for a model of a simple chopper system with a power source and an ideal shunt motor acting as an electrical load for the chopper. The behavior of the power measurement error was determined as a function of the chopper's duty cycle and back EMF of the shunt motor. Results indicate that the error is large when the duty cycle or back EMF is small. Theoretical and experimental results indicate that the power measurement error due to sampling of sinusoidal voltages and currents becomes excessively large when the number of observation periods approaches one-half the size of the microcomputer data memory allocated to the storage of either the input sinusoidal voltage or current. M.G.

N80-23216*# Honeywell, Inc., St. Paul, Minn. Technology Strategy Center.

ASSESSMENT AND PRELIMINARY DESIGN OF AN ENERGY BUFFER FOR REGENERATIVE BRAKING IN ELECTRIC VEHICLES Final Report

R. Buchholz and Anoop K. Mathur Dec. 1979 138 p
(Contracts DEN3-48; EC-77-C-31-1044)
(NASA-CR-159756; DOE/NASA/0048-79/1; TSCI0082-FR)
Avail: NTIS HC A07/MF A01 CSCL 13F

Energy buffer systems, capable of storing the vehicle energy during braking and reusing this stored energy during acceleration, were examined. Some of these buffer systems when incorporated in an electric vehicle would result in an improvement in the performance and range under stop and go driving conditions. Buffer systems considered included flywheels, hydropneumatic, pneumatic, spring, and regenerative braking. Buffer ranking and rating criteria were established. Buffer systems were rated based on predicted range improvements, consumer acceptance, driveability, safety, reliability and durability, and initial and life cycle costs. A hydropneumatic buffer system was selected. Author

N80-25209*# Ford Motor Co., Dearborn, Mich. Research Staff.

FEASIBILITY STUDY OF SILICON NITRIDE REGENERATORS

C. A. Fucinari and V. D. N. Rao Oct. 1979 58 p refs
(Contract DEN3-8)
(NASA-CR-159713; DOE/NASA/0008-79/10) Avail: NTIS HC A04/MF A01 CSCL 13F

The feasibility of silicon nitride as a regenerator matrix material for applications requiring inlet temperatures above 1000 C is examined. The present generation oxide ceramics are used as a reference to examine silicon nitride from a material characteristics, manufacturing, thermal stress and aerothermodynamic viewpoint. E.D.K.

N80-26212*# AiResearch Mfg. Co., Torrance, Calif.

ADVANCED PROPULSION SYSTEM FOR HYBRID VEHICLES Final Report

L. V. Norrup and A. T. Lintz Jan. 1980 213 p refs
(Contracts DEN3-91; EC-77-A-31-1044)
(NASA-CR-159771; DOE/NASA/0091-80/1;
AiResearch-79-16430) Avail: NTIS HC A10/MF A01 CSCL 13F

A number of hybrid propulsion systems were evaluated for application in several different vehicle sizes. A conceptual design was prepared for the most promising configuration. Various system configurations were parametrically evaluated and compared, design tradeoffs performed, and a conceptual design produced. Fifteen vehicle/propulsion systems concepts were parametrically evaluated to select two systems and one vehicle for detailed design tradeoff studies. A single hybrid propulsion system concept and vehicle (five passenger family sedan)were selected for optimization based on the results of the tradeoff studies. The final propulsion system consists of a 65 kW spark-ignition heat engine, a mechanical continuously variable traction transmission, a 20 kW permanent magnet axial-gap traction motor, a variable frequency inverter, a 386 kg lead-acid improved state-of-the-art battery, and a transaxle. The system was configured with a parallel power path between the heat engine and battery. It has two automatic operational modes: electric mode and heat engine mode. Power is always shared between the heat engine and battery during acceleration periods. In both modes, regenerative braking energy is absorbed by the battery. Author

N80-28255*# Eaton Engineering and Research Center, Southfield, Mich.

SMALL PASSENGER CAR TRANSMISSION TEST-CHEVROLET 200 TRANSMISSION Final Report

M. P. Bujold Mar. 1980 381 p

(Contracts DEN3-124; EC-77-A-31-1044)

(NASA-CR-159835; DOE/NASA/0124-1; ERC-L1B-79168) Avail: NTIS HC A17/MF A01 CSCL 13F

The small passenger car transmission was tested to supply electric vehicle manufacturers with technical information regarding the performance of commerically available transmissions which would enable them to design a more energy efficient vehicle. With this information the manufacturers could estimate vehicle driving range as well as speed and torque requirements for specific road load performance characteristics. A 1979 Chevrolet Model 200 automatic transmission was tested per a passenger car automatic transmission test code (SAE J651b) which required drive performance, coast performance, and no load test conditions. The transmission attained maximum efficiencies in the mid-eighty percent range for both drive performance tests and coast performance tests. Torque, speed and efficiency curves map the complete performance characteristics for Chevrolet Model 200 transmission. L.F.M.

N80-30228*# Ford Motor Co., Dearborn, Mich.

REGENERATOR MATRIX PHYSICAL PROPERTY DATA

C. A. Fucinari May 1980 51 p refs

(Contracts DEN3-8; EC-77-A-31-1044)

(NASA-CR-159854; DOE/NASA/0008-80/11) Avail: NTIS HC A04/MF A01 CSCL 05A

Among several cellular ceramic structures manufactured by various suppliers for regenerator application in a gas turbine engine, three have the best potential for achieving durability and performance objectives for use in gas turbines, Stirling engines, and waste heat recovery systems: (1) an aluminum-silicate sinusoidal flow passage made from a corrugated wate paper process; (2) an extruded isosceles triangle flow passage; and (3) a second generation matrix incorporating a square flow passage formed by an embossing process. Key physical and thermal property data for these configurations presented include: heat transfer and pressure drop characteristics, compressive strength, tensile strength and elasticity, thermal expansion characteristics, chanical attack, and thermal stability. A.R.H.

N80-32299*# Battelle Columbus Labs., Ohio.

DESIGN STUDY OF STEEL V-BELT CVT FOR ELECTRIC VEHICLES Final Report

J. C. Swain, T. A. Klausing, and J. P. Wilcox Jun. 1980 131 p refs

(Contracts DEN3-116; EC-77-A-31-1044)

(NASA-CR-159845; DOE/NASA/0116-80/1) Avail: NTIS HC A07/MF A01 CSCL 13F

A continuously variable transmission (CVT) design layout was completed. The intended application was for coupling the flywheel to the driveline of a flywheel battery hybrid electric vehicle. The requirements were that the CVT accommodate flywheel speeds from 14,000 to 28,000 rpm and driveline speeds of 850 to 5000 rpm without slipping. Below 850 rpm a slipping clutch was used between the CVT and the driveline. The CVT was required to accommodate 330 ft-lb maximum torque and 100 hp maximum transient. The weighted average power was 22 hp, the maximum allowable full range shift time was 2 seconds and the required lift was 2600 hours. The resulting design utilized two steel V-belts in series to accommodate the required wide speed ratio. The size of the CVT, including the slipping clutch, was 20.6 inches long, 9.8 inches high and 13.8 inches wide. The estimated weight was 155 lb. An overall potential efficiency of 95 percent was projected for the average power condition. Author

SUBJECT INDEX

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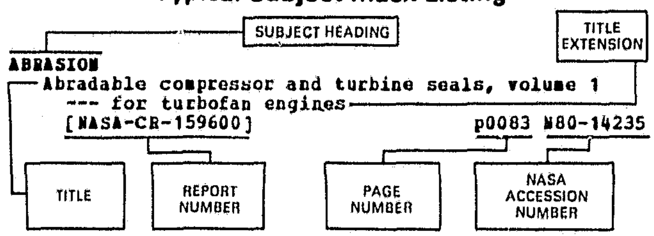

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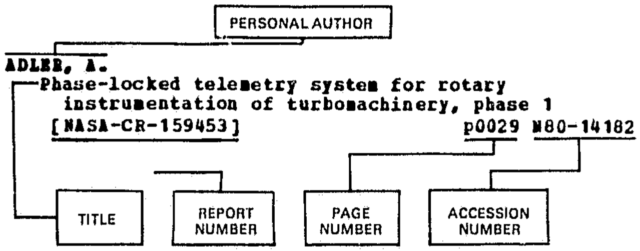

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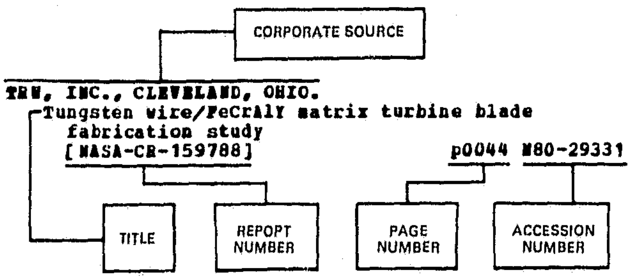

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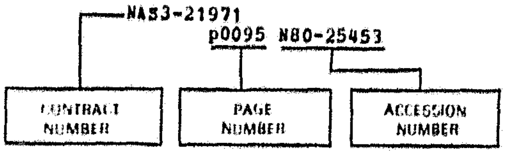

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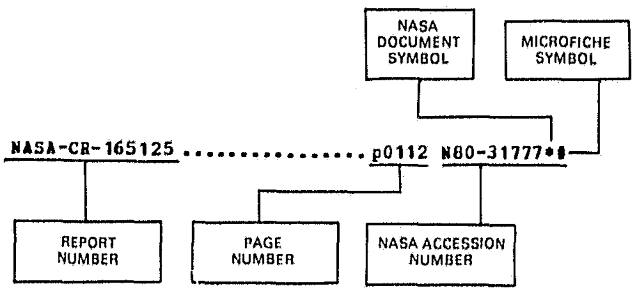

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